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Grass and Legumes versus Corn

RECENT improvements in production and handling methods in the case of both hay crops and corn, place them close to equal under many production conditions, as sources of low-cost forage.

Hybrid varieties, short-cut cultural practices, and mechanical harvesting are lowering corn forage costs. Legumes and grasses are keeping pace through new harvesting and drying practices, and as grass silage.

Individual farmers will need to know well their individual farms, livestock, storage buildings, and operating equipment, to determine which source of forage, or how many acres of each source, will represent greatest economy in their individual cases. Agricultural engineers may expect to be asked by farmers to help draw the line between combinations of conditions which favor corn and other conditions which swing the economy balance in favor of grasses and legumes. The seed and soil manipulation, environmental control, and materials handling factors, and their effective combination in a production program, are force and material relationships to which engineering principles apply.

AGRICULTURAL ENGINEERING

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Defending the Labor-Saving Principle

SOUND, scientific thought applied to practical problems of life is a comparatively new development in human history. It is still the exception, practiced by the small percentage of trained minds, and even they are subject to error in its application. The world is still ruled by emotionalism and wishful thinking. With most individuals, any scientific thoughts and products thereof which appear on the surface to be contrary to their best interests are condemned, figuratively, as witchcraft.

Engineers, including agricultural engineers, are currently being burned at the stake by many well-meaning and influential citizens for their mischievous black magic of labor-saving machinery.

Modern witch burning takes subtle forms, ranging from public apathy to prohibitive legislation. If engineers are to avoid being further barbecued over the hot fagots of public opinion, they will have to counteract the heat with cold facts in words that the public can understand, and applied to situations which directly affect the public. If agricultural engineers are to find the support they need for their work, and enjoy complete freedom to carry on within the limits of professional conduct they themselves establish, as in the public interest, they will have to show farmers, public and business administrators, and the general public the real human worth of labor saving on farms. Then machines, structures, and other combinations of materials and forces can be fairly considered on their respective merits as agencies for saving labor.

There have been numerous approaches to the problem of explaining simply and clearly the human values of labor saving. Many of them have bogged down in the complexity of economic exchange relationships, or have lost their effectiveness in vicious circles of qualitative reasoning. One of the best contributions in the agricultural engineering field is the five-year-old symposium on "How Farm Machinery Creates Employment," reprints of which are still available in limited quantity, for the information of any agricultural engineers who may not be familiar with it.

To add a view of our own we resort to an hypothetical situation. Leave out the complications of exchange and assume that every man has to make every commodity not found in nature and perform every service to be performed for himself and his family. In other words, he has available, to use and enjoy, only the immediate products of his own industry. Assume also that plenty of labor-saving machinery is freely available to use or not, as he chooses. Will it be used by the ordinary, industrious man of common virtues, who is anxious to make the best use of his God-given talents to provide for his family and himself? We believe he would use it, with pleasure, for forty hours a week or as many as necessary to provide necessities, a stock of supplies as security for the future, and as many luxuries as he could enjoy during his balance of time for rest and recreation. We doubt, too, if he would complain about the advent of any improved machine which would lighten his work, make it safer, enable him to produce a larger stock of security and luxuries, and leave him more time to enjoy them.

In this light, has the public any logical criticism against engineer-made labor-saving machinery, except that it does not save enough labor? Isn't it insecurity of employment, unsatisfactory labor conditions, lack of opportunity to produce, and failure to receive what he feels is his contribution to production that troubles the worker? And aren't these due to faulty relationships in the exchange of goods and services, rather than the fault of the machines he would like to have and to use in a situation where exchange of goods and services was not necessary?

Still labor-saving machines and the engineers who make them will be condemned as witches to a dangerous extent whenever the exchange system is out of balance, until more engineers have clearly shown and convinced more of their neighbors and non-technical associates in more words and ways, that labor-saving machines are not the source of their troubles.

Agricultural engineers are the logical ones to carry this viewpoint to farmers, their bankers, and as many of the consumers of farm products as they can reach. Public acceptance of the labor-saving principle is the only way to support and freedom of engineering progress.

Rural-Urban Balance

ONE OF the prime professional interests of agricultural engineers is understanding of agriculture and agricultural problems. It provides a basis for determining the nature of the technology and the manner of applying technology which may prove of greatest service to agriculture.

S. P. Lyle, in his address elsewhere in this issue as the retiring president of the American Society of Agricultural Engineers, analyzes the evolution of agricultural and agricultural engineering progress in relation to the progress of civilization, with particular reference to conditions in the United States. He traces the parallel growth of populations, technology, mechanization, increased production, new employment, and better living, down to a present need for thinking in terms of "rural-urban balance in opportunities and exchange of services."

It is unnecessary to review here the part agricultural engineers have had in this progress. Emphasis is warranted on the nature and direction of agricultural engineering technology suggested or implied as of probable value in helping to realize the desired rural-urban balance.

Increase in rural opportunities, to improve the balance, might include any improvement in facilities to make the farm a more desirable place to live and work, namely, comforts, conveniences, labor-saving devices, safety devices, soil and water conservation practices, planning and coordination of work, and increased net income. Most agricultural engineering work to date has had one or more of these direct objectives, and from Mr. Lyle's analysis continued effort in this direction is justified.

Improved balance in exchange of services implies increased effectiveness of farm work in terms of output to meet market demands. This is a newer field to agricultural engineers. It involves engineering the production of new crops and livestock, utilization of former waste materials, development of processing services which can be performed on farms, and utilization of surplus farm labor and products on or near the farm in construction and conservation work.

It means the broadening of farm production as to variety of products, range of services performed on each product, and extent to which each product is utilized. It means increased sensitivity and adaptability of production to changes in market demand. It means creating new market opportunities by the production of new marketable products and services. It involves the engineering technology of analysis and reanalysis of specific old and new farm labor, power, and material applications as to their values in terms of influence on yield of marketable products and on human satisfactions.

We invite special attention to Mr. Lyle's address as a contribution to the understanding of agriculture and of the technological assistance it can well utilize.

Efficiency and Other Objectives

AGRICULTURAL engineers have long advocated high operating efficiency and low unit cost of production as desirable in agriculture. Without questioning the principle, we pause to examine the extent of such desirability, and to consider whether or not efficient production, in itself, is sufficiently far reaching to be the main objective of agricultural engineers.

To the extent that a farmer can practice higher efficiency and achieve lower production costs than his neighbors, it is apparently desirable for him as an individual. It is an aid to staying in business and possibly making a profit, in spite of having to dispose of his output on a buyers' market.

To the extent that people fail to enjoy a reasonably adequate diet by reason of high food prices, low farm production cost is apparently desirable as a step toward low food prices — a step directly beneficial to the predominant urban day laborers and their dependents.

To the extent that the demand for farm products for food and for industrial uses may be elastic, low production cost would favor increased use, market demand, and opportunity for farmers to render economic service. This seems economically desirable.

To the extent that efficient, low-cost farming requires and provides opportunity for satisfying application of intelligence and for otherwise satisfactory living, it offers inducement for the highest type of farm youth to remain on farms—the source and most favorable environment for the perpetuation of a high type of population. This seems socially desirable.

To whatever extent low-cost production requires good land, it should encourage soil conservation. This was not true in the pioneer days of mining and moving, but American agriculture has passed that stage.

To whatever extent low-cost production eliminates drudgery and encourages use of mental as well as muscular energy, it would seem to be a force in human conservation.

But to the 80 per cent of American farmers who produce only 20 per cent of its farm products—those farmers who lack the inclination, adaptability, capital, land, or whatnot to substantially increase their efficiency—this offers little hope. The efficient production objective does not reach them.

And to the extent that the market for farm products is inelastic or can be expanded only slowly as a result of patient research in industrial utilization, competition for the limited market cannot greatly increase the net income of agriculture as a whole.

To the extent that agriculture involves manual operations which have not as yet yielded to mechanization, and physical factors not yet economically subject to engineering control, we have little to offer farmers to increase their operating efficiency this year or next.

Furthermore, efficiency scarcely touches the major problem of maintaining agricultural capital. C. O. Reed maintains that American agriculture is constantly losing not only an important part of its young people and of its soil, but of its capital as well. In the decade from 1920 to 1930, American farmers are said to have lost more than 36 billion dollars through their investment in sons and daughters who left the farm, by settlement of estates, and in rent and interest paid to non-farmers. This is about one-third of the gross value of their production for the period, and greatly exceeds their margin of profit over other items in their cash cost of production. It suggests that the real net income of American agriculture for the ten-year period, and probably much longer, has been a minus quantity.

At first thought it would seem that there is little which agricultural engineers can do about these losses which they are not already doing. They are working to hold the soil and to make the farm a more attractive place to live and work. They cannot freeze people or money to the farm.

There is, as yet, no clear answer to this problem, which Mr. Reed has called a problem of "maintenance or security of the farm business and life." Whether people and capital will flow naturally to a certain desirable level or rural-urban balance is a question. Apparently it merits agricultural engineering analysis of more than physical forces. It involves economic, social, and psychological forces. Understanding of the way these forces are working might show ways of controlling them, and of saving farm people much unnecessary human and money cost in adjusting their lives and efforts to changes in conditions. It might show high production efficiency and low unit cost of production to be logical parts of a desirable broader objective of effective farm living, with new and increased opportunities for agricultural engineers to help more farm people enjoy more of the satisfactions of life for which all people work and hope. It seems worthy of more of the high order of thought which Mr. Reed has given it.

Air Conditioning for Cows and Humans

A POPULAR metropolitan daily recently had its editorial funny bone tickled by the idea of cow stables being air conditioned while so much remains to be done in getting air conditioning applied to human habitations. Apparently cows were being given precedence over humans in the concern of certain technologists, namely, agricultural engineers, for the comfort and wellbeing of living things.

Probably few cows will suffer prolonged discomfort by reason of this editorial levity; and we hope and believe that the air conditioning of human habitation will not be delayed by agricultural engineering interest in air conditioning for cows. The incident assumes importance only as an indication of the need for technologists to point out clearly the human objectives of their work.

The public finds difficulty in following the indirect methods of technology. It might easily conclude that the humane societies take adequate care of animal comfort, and that any research on the subject must be a boondoggling waste of public money.

But if it is clearly explained that air conditioning for cows is being studied with a view to improving the quality and lowering the cost of dairy products for human use, so that more humans, in fact, may be able to afford air-conditioned homes and other modern comforts, the public may see the point and at least avoid active opposition to such research.

Engineering Evolution

By S. P. Lyle

ENGINEERING evolution is so much taken for granted that we cannot imagine the existence of engineering services to society without inherent technical progress. The terms "economic evolution" and "social evolution" are common enough on the radio, in the press, and in daily conversation. Development and progress in our economic and social knowledge and behavior is fervently hoped for by all, but is disputed occasionally because changes in these fields, viewed by some observers as progress, may be questioned by others. Engineering technical progress, however, is not in dispute because it is measurable, and its tangible evidence is so apparent in new devices for transportation, communication, construction, equipment, and materials that a suggestion of evolution in engineering seems superfluous.

SAMUEL P. LYLE
PRESIDENT A.S.A.E. 1938-39

Air transportation, radio, television, and other technical achievements are the fruit of that organization of science and skill which is engineering, and which has become a rich heritage of this age to be used intelligently and honorably, to be improved and perfected, and to be passed on to benefit the human race. Engineering adapts science to human use. It is inseparably scientific, economic, and social. Since it is not solely technical, it may be profitable to examine engineering in relation to social and economic evolution.

To clarify the scope of its interest we have a definition long used by this society which not only describes engineering but also embodies a broad code, namely, "the science of utilizing the forces and materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith". The first part of this definition is founded on basic science through which we discover and measure the forces and materials of nature in order to adapt their use for the benefit of man. The second part, "the art of organizing and directing human activities", accords with the popular conception of engineering which has developed use of the verb "to engineer", meaning to manage competently. The scientific and economic elements are inherent in engineering. The social and executive elements are essential to the widespread acceptance of engineering service. Engineering evolution accomplishes progress in all these related elements of our definition.

Industrial revolution is the product of the evolution of engineering from its scientific sources. There are times when industrial revolution is praised for its gifts to civilization, and there are times when it is blamed for social maladjustments. In general its overall benefits to mankind are granted by all, even by those who proclaim their apprehensions to the public, for invariably the criticisms are specifically proposed to preserve a status quo in some unfavorable cost or labor situation which technology has not caused, but which may present the opportunity and sometimes the necessity for mechanization in order for the industry to survive.

Engineering, the practical partner of science, not only recognizes sociological obligations but contributes its share in terms of social betterment. A publication of the National Industrial Conference Board, "Machinery, Employment, and Purchasing Power", reports from U. S. Census information that while population increased 218 per cent between 1870 and 1930, persons engaged in gainful occupations increased 290 per cent. In brief, while population increased threefold employment increased almost fourfold.

Quoting a paragraph in explanation, "The period from 1870 to 1930 witnessed the development of railroads, automobiles, airplanes, tractors, harvesting machinery, electric power, typewriters, telephones, radio, illuminating and heating gas, modern plumbing, refrigeration, canning, central heating, and innumerable products and services which were previously unknown or were luxuries not available to the mass of the people. To produce these various goods and services, with generally shorter hours of work, has required the use of machinery to increase the output of the working population, and an expansion in the working population itself." The total volume of production in manufactures, mining, and agriculture was 829 per cent larger in 1929 than in 1869, production per capita increased 210 per cent, and the output per gainful worker rose 281 per cent. The figures for agriculture show the least increases, 321 per cent in volume, 31 per cent gain in production per capita, and a gain in productivity of 178 per cent per gainful worker. Commenting on the figures the report states that the history of these 60 years shows that without the help of machinery the vast increase in the output of goods on which our high standard of living is based could never have been achieved.

The report further notes that the wage earners in 18 new manufacturing industries begun since 1879 accounted for one-eighth of all employment in manufactures in 1929. This increase refers only to manufacturing employment whereas the automobile and electric industry, for example, give employment to several times as many people outside of manufacturing, and it has been estimated that one-fourth of the gainfully employed in 1929 owed their jobs to industries developed since 1880.

Even more recently increasing employment has depended on new industries. The General Electric Company reported to its stockholders during a year of the depression period that 60 per cent of its business was in products which were not available to the public ten years before that

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Address of the President of the American Society of Agricultural Engineers before the 32nd annual meeting of the Society at University Farm, St. Paul, Minn., June 20, 1939. Mr. Lyle (Fellow A.S.A.E.) is principal agricultural engineer, in charge of agricultural and home economics section, Extension Service, U. S. Department of Agriculture.

time. The 1937 annual report to Du Pont stockholders states that 40 per cent of the company's total 1937 sales volume was in twelve lines brought on the market during the previous ten years. During this period its employment of workers on new products increased from 10,700 to 18,000; its investment in facilities for manufacturing these products increased from $65,000,000 to $174,000,000, and the composite reduction in sales price on these products was approximately 40 per cent.

Let us examine the magnitude of some new industries to better appraise their social values. The 1937 figures of the Automobile Manufacturers Association show a total of 6,037,000 persons gainfully employed in the automobile industry, of which over half are truck and bus drivers. Less than 600,000 are actually employed in manufacturing motor vehicles and tires and refining petroleum while nearly twice that number are employed in sales and service work. And about the same number, (1,200,000 persons) are employed on federal and state roads, insurance and financing operations, and as taxi drivers and chauffeurs. Forty years ago less than 1,000,000 workers were employed in the production, operation, and maintenance of the carriage and wagon industry, exclusive of farm labor. The gain in urban employment is over 5 million.

The benefit to consumers resulting from this industry is, however, the basis upon which its continuing services depend. Here is its present position. Motor vehicle registration in 1938 in the United States was 24,150,000 cars and 4,250,000 trucks. The total 29,400,000 vehicles is 68 per cent of the world registration. The gasoline consumption, 19,200,000,000 gallons, has been estimated to have furnished fuel for over 250,000,000,000 miles of highway travel last year. These are remarkable figures, but the peak of domestic consumption has evidently not been reached, as the highway systems are expanding and improving, hence we may assume that employment in this field will increase.

THE PREDICTION OF TECHNOLOGICAL DISPLACEMENT OF EMPLOYES WAS NOT BORNE OUT

Another well-known example is electric service which has increased from the meager output of the first scattered small central service stations to over 115 billion kilowatt-hours of energy production in the United States last year. This is at least ten times as much energy as the 16 million horses and mules in this country exert in useful work, but to date practically none of it has been applied to supplant animal power. The electric industry has continued to expand in response to consumer demands. During 1938, approximately one-half billion dollars was spent for new construction and modernization by the electric industry, exclusive of federal projects, and rural electric cooperatives and similar organizations have invested over $130,000,000 from rural electrification funds in the current fiscal year.

The electric industry is a little more than fifty years of age, but there are a number of recent related developments which are new industries in themselves, for example, the dial telephone and electric refrigeration. An interesting feature about these is that the prediction of technological displacement of employees was genuinely feared and considered inescapable. But what has happened? In the decade of the 1920s dial installations increased from 3 per cent to more than 30 per cent, while the number of operators increased from 190,000 to 249,000; telephone calls increased more than 100 per cent, and the number of linesmen increased nearly 100 per cent. For the same decade while the electric refrigerator was being introduced, the public evidently was stimulated to increase ice refrigeration also, for by 1930 the number of ice dealers had increased 237 per

cent over the census for 1920. The production of ice refrigerators also increased correspondingly while the 10,000,000 electric refrigerators were manufactured.

It is important that these facts should be appreciated by the employable people of our country as the benefits in this country are unique for the population as a whole. For example, 68 per cent of the motor vehicle registrations of the world are in the United States, but we have only 6 per cent of the world population. Of telephones we have half of all there are in the world. There are more than 19,500,000 telephones in this country. Germany, Great Britain, France and Japan, listed in order of their number of telephones have all together less than one-half the number of telephones in the United States. China, British India, and Russia, which together have half the earth's population, have only three-fourths as many telephones as New York City, which has 1,569,337.

This spring Congress celebrated the 150th anniversary of the adoption of our federal constitution. The freedom which our forefathers had sought and won finally at Yorktown eight years before the constitution was adopted, was liberation from the colonial status which hindered industrial development of this country's rich natural resources. The population of the United States in 1789 was about 3 million. It has increased to over 130 million since we shook off the colonial function of supplying raw materials and developed our industrial independence.

Population increases, however, were by no means peculiar to the United States. The world population has increased 200 per cent in the two centuries from about 1740 to date, and the population of Europe has increased about 270 per cent in the same time. The increase in numbers for the past 200 years is for the area of the United States from less than 3,000,000 in 1740 to 130,000,000 today; in Europe from 135,000,000 in 1740 to 500,000,000 today, and for the world from about 600,000,000 in 1740 to 1,800,000,000 today. In brief, our population today is almost

the same as that of Europe 200 years ago, and that of Europe today would have almost covered the earth 200 years ago.

In Asia the agricultural areas have experienced the principal population increases, so that today the world's three largest areas of dense population are Europe, India, and the mongolian area composed of China and Japan. Obviously world trade and agricultural as well as industrial revolution have had much to do with making possible the existence of three times as many people on the earth today as were on it at any time previous to 1740, but it is notable that the people of the industrially developed countries have been practically the only ones which have gained in the standard of living, favorable wages and hours, increasing ease of tasks, and comfortable working conditions.

Population gains accompanied by technological evolution have netted unsurpassed cultural gains, while population gains accompanied by increases in production of agricultural and other raw materials alone, have apparently not improved the lot of the general population to any comparable degree.

The Permanent Agricultural Committee of the League of Nations in its 1938 report on "Social Problems in Agriculture" states, "With a view to the study of the factors influencing the standard of living of the agricultural population, countries may be classed into three groups.

"First, there are the predominantly industrial countries which are in some cases, on balance, importers of foodstuffs and agricultural raw materials. In such countries governments can to a certain degree take measures to maintain certain levels for agricultural prices and thus directly affect the economic position of those engaged in agriculture.

"Second, there are many countries which are relatively advanced in economic structure but are predominantly agricultural exporting nations and where in consequence the economic position of agriculture must depend upon world prices.

"In both these groups the progressive application of scientific research to the problems of agriculture tends towards production exceeding the effective demand of the world's import markets. Continuous progress is being made in the improvement of agricultural machinery, and this is increasing productive capacity per individual engaged in agriculture while the equally rapid progress in the technique of crop and stock raising, and in the control of diseases and pests, is increasing the yield of farm products per unit of area.

NEW DEVELOPMENTS IN GENERAL MORE WIDELY AVAILABLE TO PEOPLE IN THIS COUNTRY

"The third group consists of countries in which lack of capital and of educational facilities has prevented the wide application of science to agriculture and where this great paradox is found, namely, that it is the food producers themselves who suffer most from malnutrition.

"The Committee recognized that the economic problems of these three groups of countries will sometimes be found to require different forms of solution. Nevertheless, it was recognized that the form of economic action which would have the greatest effect upon the social welfare of the agriculturist, no matter to which group of countries he belonged, was action to improve the general standard of living of all classes in all countries."

New developments in general will be found to be more widely distributed and available to the people of our country than to other peoples, but there are exceptions, including the people on that 49 per cent of our farms which produce only 11 per cent of the agricultural goods for market. Some of these farms have been dependent for 150 years on technological improvements in cotton ginning, spinning, weaving, cotton seed processing, transportation, communication, and exchange to find a market for their product in competition with world trade. These same advantages are now widely available in other cotton-producing countries, and the Egyptian and Brazilian packaging and marketing practices are preferred by foreign buyers. Cotton production, however, remains on a primitive one mule and hand production basis. In such a situation farmers and the cotton industry are impelled toward improving their production efficiency, to maintain the American standards of living, in spite of low prices.

It is expected that agricultural evolution will bring about gradual changes on low income farms through encouraging larger acreages for family size farms, with at least two mule power for every farm laborer, and that type of thrift and enterprise which characterizes thousands of family-size diversified small general-purpose farms in this country and in Europe. Agencies of the Department of Agriculture in cooperation with the state agricultural colleges, the Public Health Service, the Office of Vocational Education, and local agencies are concerned about this special agricultural social problem of shielding these farm families from too swift changes in what may be the acceleration of the industrial development of the South. A great social problem exists not only there but throughout the nation, which must be dealt with intelligently. However, the agricultural evolution is forward and hopeful with systematic planning now in effect through official cooperation of federal, state, and local agencies concerned with land use for the welfare of the people.

FARM MECHANIZATION A BLESSING IF IT REPLACES LABOR LOST TO INDUSTRIAL DEVELOPMENT

The natural trend is also fundamentally progressive for according to "Social Problems in Agriculture", previously quoted, "The Committee noted that it is estimated by the statistical section of the Office that in the whole world some 865,000,000 persons are 'gainfully employed'. Out of this total no less than 550,000,000 persons are 'gainfully employed' in agriculture. Thus agriculture represents more than 60 per cent of the economic activities of mankind." This compares with less than 25 per cent in the United States, the total gainfully employed being 46,295,000, with 11,244,000 employed in agriculture. Certainly a strong trend in the opposite direction toward the world situation of 60 per cent of the total workers employed in agriculture would be accompanied by alarming industrial decadence, disastrous to living standards. On the other hand, the living standards of backward farmers in the United States can be expected to rise with any changes which relieve the population pressures on these farms.

Farm mechanization is counted a blessing, if it comes to replace labor lost to industrial employment. It has been advanced most rapidly in the past, with wheat and other crops, because of labor scarcity or unreliability at harvest time. Dependability is mechanization's principal attraction for farmers. Unemotional and tireless reliability to perform tasks on time is what farmers seek in power and machinery. They prefer to pay their hired men higher wages in the factory production of these new time savers, rather than to pay them lower wages for less efficient work on the farm. The net saving in national employment is not great, for in addition to the manufacturing, the mining, transportation, commercial, and service employment must also be included. The machine gives the farmer labor on deposit for use on

demand. That is why he buys it and will continue to buy it, while half his sons and daughters go to town to join the population which makes, sells, or transports machinery and other modern conveniences and services. That situation, it seems, is better than a preponderantly agricultural economy, at least for Americans.

With reference to agricultural engineering progress, a high standard has been set in field machinery covering the production of the principal crops, except cotton and tobacco. In fact, efficiency measured in man-hours per acre for the production of wheat has reached a point where further changes in man-hours per acre will effect little saving, and emphasis is being directed more toward decreasing the man-hours per unit of yield. Soil conservation and improvement offers the solution to controlling erosion and improving yields. Engineers are interested in both the inauguration and maintenance of conservation practices. Mechanical field practices should include provision for all phases of the maintenance of erosion control and soil improvement practices as part of the regular farming routine. This may increase man-hours per acre, but should eventually result in the best efficiency for permanent production.

The optimum use of power per farm laborer is another problem in which rapid progress is being made. We have abundant evidence to show that labor income is proportional to the amount of horse power available per farm worker. And we find that principle may be readily applied to farms which can use efficient power units in field work. But where the type and size of farm limit the use of field power, we may still in many cases increase the labor income by the application of stationary and automatic power to productive tasks in livestock enterprises or some other diversity in production. The engineering factors may depend for efficiency upon suitable uses of electricity for operating irrigation, poultry, dairy, refrigeration, soil heating, or other equipment. Rapid expansion of rural electric service offers new opportunities for employment for young people through the development of new farm and rural industries close to the surplus rural labor supply and the source of raw agricultural materials.

AGRICULTURAL ENGINEERING MODERNIZING RURAL LIVING IN THE MOST ACCEPTABLE SENSE

Agricultural engineering is also modernizing rural living in the most acceptable sense. It offers the benefits of engineering modernization in harmony with the rural setting and the needs of farm enterprises. It is best for farm families and for the national welfare to bring modern conveniences, comfort, efficiency, and health into farm homes to foster a good rural-urban balance in opportunities and exchange of services.

Using the science of agricultural progress and the counsel of economists and sociologists, let us perform the engineering function in organizing for progressive changes, acceptable to and supported by farmers on sound productive bases. Initiative, change, and improvement are needed in agriculture in the future as in the past. More research is needed, but also agricultural industrial planning is needed, not limited to the unit farm management, but in the larger sense of industrial development.

Since old markets for surplus products can not be retrieved, new employment for surplus labor must be developed if employment is to make any gains on population increases. In general, it will be recognized that a growing industry of any character old or new from agriculture to television will increase employment and a stationary as well as a declining industry will curtail employment. Obviously we need continually new and growing industries, for all industries tend to reach a state when demand for the product becomes limited and further increases in efficiency in that field of endeavor lead to a lower labor requirement.

New products have the advantage of increasing the capacity of the public to consume goods. The development of new uses for agricultural products is therefore of great interest in the further evolution of agricultural engineering services to society. Since the topic of new uses is presented by others on our program I shall not discuss it, except to recognize that some of the best markets for agricultural products lie right on farms or close to them. I refer to materials, some of which might be new, for the insulation, repair, and painting of houses and farm structures. The labor, materials, and market are convenient for efficient and low-cost utilization in many areas of the country. There are certainly millions of town and farm homes upon which the expenditure of $100 or more would be a paying investment today. Reconditioning farm buildings is no less needed. Can not surplus farm labor be directed to these ends for housing and building improvement, incidentally developing in this way new markets for linseed, soybean, and pine oils, turpentine, cotton, waste agricultural by-products, and lumber, and in addition for non-agricultural materials such as the painting pigments and equipment, and the tools, hardware, and other necessary accessories for building repair and modernization.

Agricultural engineers have an opportunity now as never before to serve society by organizing and using human resources efficiently, as well as the forces and materials of nature. We recognize human erosion, can we not conserve men as well as soil? In this cause we offer constructive cooperation to the economists and sociologists who are deeply concerned with this problem for the welfare of the least secure of our population, and the general welfare of our nation.

Engineers possess no magic powers to create to order immediately new markets and consequent employment to take the place of loss of markets and loss of employment due to unavoidable causes not related to engineering, but we do acknowledge that evolution in science and engineering together create wealth and new employment in a field which recognizes no limits to its frontiers. Engineering evolution is a dependable progressive factor in our agricultural as well as national economy, which is directing its force with increasing effect toward profitable efficient re-employment as well as gradually bringing to every home benefits and services which even kings could not command fifty years ago.

Coordination and Research Needed

FINDING concrete opportunities for the industrial processing of farm crops is not just a matter of pointing the finger; it is necessary to analyze the agricultural problems of producing satisfactory grades of the crops available, to study thoroughly the markets in which the crops might be sold in processed form, and to solve the engineering problems in production, transportation, and processing operations. . . . . We have found little record of engineering, agricultural, and market research as directed toward uncovering specific opportunities for manufacturing enterprises capable of operating successfully in rural areas. . . . . It is hoped that the engineering development of new processes and the necessary machinery may contribute to the enlargement of the body of knowledge and experience available regarding the closer coordination of industry and agriculture.—J. P. Ferris and R. B. Taylor in *Mechanical Engineering*.

Ground Water Resources

By Kyle Engler and Deane G. Carter

RESEARCH studies of factors involved in the water supply for rice irrigation have been conducted over a period of 10 years by the University of Arkansas college of agriculture[1]. The principal rice-growing area of the state is the Grand Prairie region of east central Arkansas, which has produced an average of 99,000 acres of rice annually since 1905, and an average for the past 10 years of 124,000 acres per year.

A small amount of irrigation water is drawn from the deep wells of the Tertiary sands, and an increasing use is made of surface water supplies, principally reservoirs, bayous, and streams. About 90 per cent of the irrigation water, however, is obtained by pumping from the Pleistocene sands.

The enormous quantity of water withdrawn from the Pleistocene sands has resulted in a gradual but persistent decline in the water level in most wells throughout the area. This condition affects the 1,000 or more producers, and has created a demand for full information, and a solution of the problem of water supply. The investigations reported include studies of water requirements, withdrawal, and ground-water conditions[2].

Water Requirement. The average depth of irrigation water required to grow an acre of rice was determined from 30 records, covering the pumping seasons of 1928, 1929[3], 1937, and 1938. Automatic water-stage recorders and weirs were used to measure the amount of water. Rain gages were located near each test area. The average amount of irrigation water pumped was 20.8 in, and the rainfall for June, July, and August averaged 9.6 in, for a total of 30.4 in of water required (See Table 1).

Withdrawal. When the seasonal rainfall is correlated with the depth of water applied by pumping, the correlation

TABLE 1. WATER REQUIREMENT FOR RICE IRRIGATION

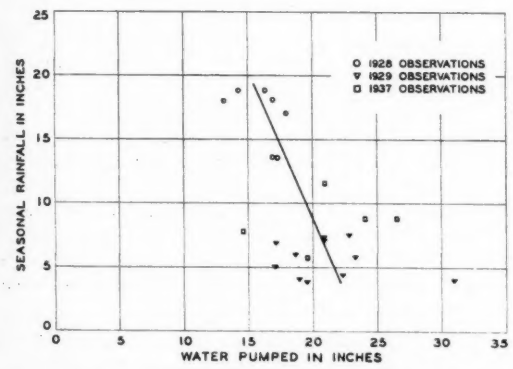
Plant No.	Period of operation, days	Average flow per min, gal	Area irrigated, acres	Average flow per min per acre, gal	Depth of water applied: Pumped, in	Rainfall, in	Total, in
			Season of 1928				
3	60.4	512	97.0	5.3	16.9	13.6	30.5
4	56.4	539	93.8	5.7	17.2	13.6	30.8
5	84.0	526	163.6	3.2	14.3	18.8	33.1
6	72.4	862	203.0	4.2	16.3	18.8	35.1
7	39.6	804	93.8	8.6	18.0	17.1	35.1
9	55.1	786	174.8	4.5	13.1	18.0	31.1
			Season of 1929				
3	74.6	503	85.0	5.9	23.3	5.8	29.1
4	67.9	543	63.2	8.6	31.0	4.1	35.1
6	93.2	790	165.0	4.8	22.8	7.5	30.3
7	58.6	566	101.0	5.6	18.9	4.2	23.1
10	74.5	723	134.0	5.4	20.8	7.4	28.2
11	60.6	377	64.3	5.9	18.7	6.1	24.8
12	52.4	458	65.1	7.0	19.6	3.8	23.4
13	44.2	471	64.2	7.3	17.2	7.0	24.2
14	83.0	2038	402.0	5.1	22.3	4.5	26.8
			Season of 1937				
1	75.3	705	112.5	6.3	25.0	9.0	34.0
5	54.8	739	108.9	6.8	19.7	5.8	25.5
6	51.4	1075	139.4	7.7	21.1	11.6	32.7
19	31.8	767	88.0	8.7	14.6	7.8	22.4
20	62.0	703	80.3	8.7	28.8	9.0	37.8
			Season of 1938				
1	79.2	610	97.4	6.3	26.3	7.7	34.0
2	82.0	718	144.0	5.0	21.7	7.6	29.3
3	56.8	685	103.7	6.6	19.9	7.9	27.8
4	53.2	830	92.6	9.0	25.3	7.9	33.2
5	58.2	428	70.8	6.0	18.7	11.4	30.1
6	53.6	1457	182.2	8.0	22.8	14.0	36.8
7	58.2	475	61.7	7.7	23.8	8.3	32.1
8	89.7	521	106.2	4.9	23.4	8.3	31.7
9	52.8	635	89.1	7.1	20.0	10.8	30.8
10	66.2	545	80.1	6.8	23.9	10.8	34.7
Average	63.4	713	117.6	6.4	20.8	9.6	30.4

Research Paper No. 636, Journal Series, University of Arkansas, released for first publication in AGRICULTURAL ENGINEERING. Mr. Engler (Mem. A.S.A.E.) is assistant agricultural engineer, and Mr. Carter (Fellow A.S.A.E.) is professor and agricultural engineer, Arkansas Agricultural Experiment Station.

[1]This study is, in part, the result of studies made in cooperation with the Geological Survey, United States Department of the Interior; the Arkansas Geological Survey; the Federal Land Bank of St. Louis; and various organizations and individuals at Stuttgart, Arkansas.

[2]A more detailed analysis is included in Ark. Agr. Exp. Sta. Bul. 371, Problems of Water Resources for Rice Irrigation, by Deane G. Carter and Kyle Engler (1939)

[3]Clayton, B. S., Cost of pumping and duty of water for rice on the Grand Prairie of Arkansas, Ark. Agr. Exp. Sta. Bul. 261 (1931)



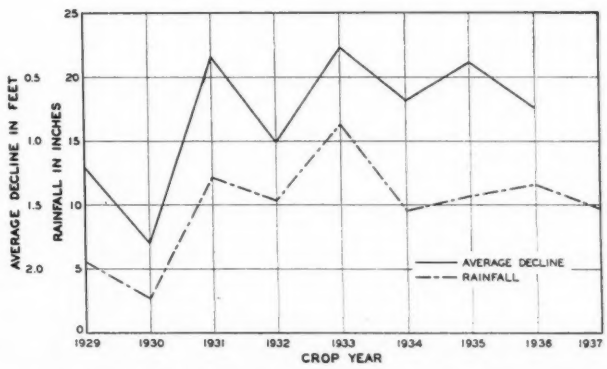


FIG. 1 (LEFT) CORRELATION OF WATER PUMPED AND RAINFALL FOR JUNE, JULY, AND AUGUST, IN THE GRAND PRAIRIE REGION OF ARKANSAS. FIG. 2 (RIGHT) COMPARISON OF AVERAGE YEARLY DECLINE IN WATER LEVEL WITH RAINFALL DURING JUNE, JULY, AND AUGUST IN THE SAME REGION

TABLE 2. ESTIMATED IRRIGATION WATER USED, GRAND PRAIRIE REGION, ARKANSAS, 1905-1937

Year	Estimated area irrigated,[1] acres	Rainfall,[2] in[3]	Estimated water pumped Per acre,[4] acre-feet	Total,[4] acre-feet[5]
1905	460	17.22	1.37	1,000
1906	4,240	20.39	1.25	5,000
1907	6,000	7.78	1.71	10,000
1908	11,400	7.36	1.73	20,000
1909	28,000	6.19	1.76	49,000
1910	48,000	14.89	1.46	70,000
1911	57,300	18.23	1.32	76 000
1912	72,600	10.67	1.60	116,000
1913	83,800	2.91	1.88	158,000
1914	74,100	12.12	1.55	115,000
1915	80,000	16 09	1.37	110,000
1916	100,000	8.90	1.67	167,000
1917	117,000	9.68	1.64	192,000
1918	136,000	9.36	1.65	224,000
1919	126,000	9.75	1.63	205,000
1920	145,000	10.29	1.61	233,000
1921	100,000	9.34	1.65	165,000
1922	123,000	7.50	1.72	212,000
1923	110,040	13.09	1.52	167,000
1924	130,560	4.45	1.82	238,000
1925	142,506	4.92	1.80	257,000
1926	161,015	8.67	1.68	271,000
1927	144,115	15.82	1.41	203,000
1928	131,051	15.11	1.44	189,000
1929	129,120	5.54	1.78	230,000
1930	141,260	2.56	1.89	267,000
1931	145,760	12.19	1.54	224.000
1932	126,769	10.24	1.61	204,000
1933	120,359	16.55	1.39	167,000
1934	109,789	9.77	1.63	179,000
1935	105,304	10.72	1.60	168,000
1936	119,077	11.61	1.57	187,000
1937	114,952	9.67	1.64	189,000
1938[6]	115,000	11.45	1.55	178,000
Totals	3,359,507			5,446,000

[1]Acreage from 1905 to 1928 from "Ground-Water Supplies for Rice Irrigation in Grand Prairie Region, Arkansas", D. G. Thompson; from 1929 to 1933 acreage from "Arkansas Crops", issued by U. S. Department of Agriculture, Bureau of Agricultural Economics, division of crop and livestock estimates, in cooperation with Arkansas State Plant Board, Bureau of Crop Statistics; from 1934 to 1937 from AAA records.

[2]Rainfall from U. S. Weather Bureau records, Stuttgart, Arkansas, for June, July, and August.

[3]Mean for 50-yr record 11.15 in. Highest seasonal rainfall occurred in 1906 with 20.39 in; lowest seasonal rainfall occurred in 1930 with 2.56 in.

[4]Calculated from graph, Fig. 1.

[5]To nearest 1000 acre-feet.

[6]Estimated.

coefficient is –0.486, which is highly significant for the sample used, and therefore this relation as a means of estimating the total withdrawal of ground water is statistically sound. By taking the rainfall for June, July, and August at Stuttgart as the average rainfall for the area, the average depth of water applied by pumping is taken from the regression line (Fig. 1). The average depth multiplied by the total acreage gives the estimated withdrawal from the Pleistocene sands (Table 2).

Ground Water Conditions. The decline in the ground water level due to the withdrawal of water for irrigation is not uniform, but varies from year to year, and according to the locality. Data on measurements in 97 wells in 1929 and 1937 showed a lowering of the water surface which varied from an average of less than 0.5 ft around the border, to more than 1.25 ft near the center of the area. In the 1937-38 year the variation in water level in 400 wells ranged from a gain of one foot to a loss of slightly more than 1.7 ft. The gain in water level occurred along the

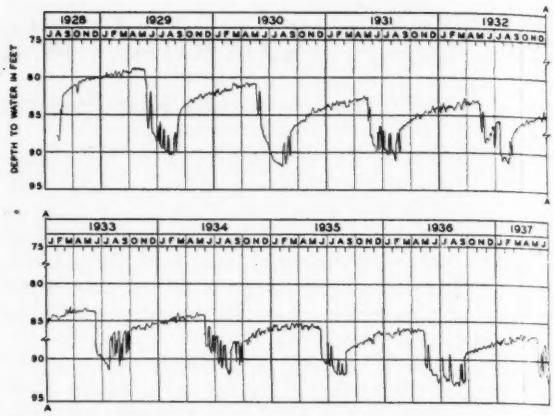


FIG. 3 FLUCTUATION OF GROUND WATER LEVEL IN TYPICAL WELL, GRAND PRAIRIE REGION, ARKANSAS, ADAPTED FROM AUTOMATIC WATER-STAGE RECORDER CHARTS

White River, where the river stage has a decided effect on the depth of water in wells.

The average decline in the water level was 0.8 ft per year, as determined by measurements in 38 wells for which records were complete from 1929 to 1937. The minimum decline was 0.25 ft for 1933-34, and the maximum was 1.8 ft for 1930-31.

Fig. 2 shows the annual decline in water level for the wells measured, together with the rainfall during the corresponding irrigation seasons. It is evident that the rainfall during the pumping season was an important factor in determining the extent of the annual decline in water level. It was also noted (Fig. 1) that the rainfall affects the amount of water pumped. By correlating the rainfall and acreage it is probable that the annual decline in water level could be estimated closely. The less than average declines in 1931 and 1934 may be accounted for by the sharp acreage reductions that occurred. In 1936 the greater decline resulted from an increase of about 14,000 acres of rice.

Typical Ground Water Condition. The typical variations and fluctuations in the ground water are shown from the record on one well (No. 280) on which a continuous chart record has been kept since August 11, 1928. The record shows that the highest level reached each year is lower than for the preceding year, and also that the lowest level reached during the pumping season is generally lower in each succeeding year. The depth to water, based on the highest spring level, dropped from 79.05 ft in 1929 to 86.29 ft in 1936, or a total of 7.24 ft in 8 yr.

A generalized graph of the chart record from this well is shown in Fig. 3. The continuous chart records reveal six important and interesting changes in the ground water levels:

1 There is a daily fluctuation ranging from a few inches to as much as a foot or more, due to barometric pressure changes

2 There is a major drop in water level at the beginning of the irrigation season

3 A sudden drop occurs when nearby pumps are started, and, conversely, there is a sudden rise when these pumps are stopped

4 A gradual decline occurs as the pumping season progresses

5 A rapid rise immediately follows the close of the irrigation season *(Continued on page 266)*

Production Possibilities of Alcohol for Engine Fuel

By Dr. Harry Miller

USE OF alcohol in motor fuel is one of the several methods that have been proposed to broaden the market for agricultural products. That agriculture needs a greater market for its products is evidenced by production curtailment and low prices. Regardless of the price structure, the extent of the food market remains practically constant. A relatively small surplus, for that reason, usually causes extremely low prices for agricultural products, with a resulting loss in buying power in agricultural communities. How this can reflect throughout the general economic structure of the nation is readily understood.

The farmer has essentially three types of materials to offer industry, namely, protein, vegetable oils, and carbohydrates. From the standpoint of soil conservation, industrial utilization should be limited to the two latter because they are built up by nature from water, carbon dioxide, and sunshine. These resources are renewed every year.

Alcohol is made from carbohydrates, namely, sugar and starch. The yield of alcohol from any material is in direct proportion to the sugar and starch content. In good plant practice 100 lb of starch will yield 7½ gal of alcohol and 47 lb of by-product carbon dioxide. The most concentrated form of starch that the American farmer has to offer is grain. Grain contains, besides starch, protein, fat, minerals, and crude fiber. These are recovered as a dry meal and known as distillers grain. They may also be fed wet, as discharged from the distillation equipment, supplemented with roughage such as corn fodder or straw. A bushel of corn or sorghum grain may be expected to yield the following products and amounts:

Alcohol	2.4 gal
Distillers grain	16 lb
Carbon dioxide (total yield)	15.12 lb
Carbon dioxide (easily recoverable)	12.5 lb

The problem of interest to us as agricultural engineers is to produce these products as cheaply as possible. This can be accomplished by improvements leading to more economical production of grain and improvements in the processing plant.

Grain sorghum ranks among the best for the production of ethyl alcohol. In drought and insect resistance it far surpasses corn, and for those reasons its popularity has increased tremendously in the semiarid regions of the country. The Texas panhandle region last year produced 75,000,000 bu of this grain. It is surprising to know that a large portion of this was harvested by driving a wagon down the row and cutting the heads by hand. This method of harvesting is expensive. The growing habits of this plant introduce a few problems. The grain in the head matures but the stalks remain green and succulent until frost kills the plant. One manufacturer has offered a heading machine that attaches to the side of a wagon box and receives its power through a belt from the rear wheel of the wagon. The heads are elevated into the wagon box and hauled from the field. The machine works fairly well on low-growing varieties of grain sorghums such as the milos. However, the varieties that make the better ensilage grow from 5 to 8 ft tall. I think there is justification for a machine on the order of a corn binder, equipped with an elevated cutting mechanism to cut off the heads in addition to the regular cutting mechanism. A conveyor system could easily be arranged whereby the heads could be loaded on one conveyance to be threshed and marketed later, and the stalks loaded on another to be used as ensilage or fodder. Proper equipment would no doubt encourage the production of grain sorghums in regions subject to frequent droughts because grain sorghums have produced fair yields where corn has been a total failure. This would do much toward maintaining the constant supply of raw material that industry requires.

Methods of lowering costs must also be sought in the processing plants. In the production of alcohol from grain, one of the most expensive operations is the conversion of the starch to sugar, preparatory to fermentation. At the present time this is accomplished by mixing about 8 per cent ground sprouted barley with the ground and cooked grain. The sprouted barley contains an enzyme that converts the cooked starch into sugar. In order to obtain maximum effect, the barley must be sprouted at a temperature lower than 57 F (degrees Fahrenheit). This involves considerable expense. A method that might be used in the so-called mold saccharification process. A material such as wheat bran is sterilized and inoculated with suitable types of mold spores, such as aspergillas oryzae. After about 48 hours under controlled conditions the mass is covered with a moldy growth. This also contains the necessary enzyme for the conversion of starch to sugar. It is much cheaper than malted grains and in the laboratory it appears to be highly satisfactory, as far as production of alcohol is concerned. It has not as yet been determined whether it will adversely affect the palatability or quality of the by-product distillers grain. If experience shows no bad effects from the mold carried over to the distillers grain, considerable saving can be effected.

Fuel cost is also a considerable item in the processing of grain to alcohol and its by-products. The distillation units, especially, are not as efficient from a heat consumption standpoint as they should or can be. Research on that equipment has not been as extensive as would be desirable. The units represent considerable investment and few designers have dared to vary from established practice. It is hoped that some research agency will make an intensive investigation of this type of equipment and develop it to the maximum degree of efficiency.

Valuable contributions to the industry might be made through research leading to the utilization of by-products. Distillers grain is recognized to be one of the most desirable feed supplements for dairy cattle. The supply has been very limited and feeders are reluctant to change to

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Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at St. Paul, Minn., June 20, 1939. Dr. Miller (Mem. A.S.A.E.) is a consulting agricultural and chemical engineer, and was formerly assistant director of research for the Chemical Foundation of Kansas Co.

something new. Considerable demonstration and sales effort is necessary to get the output utilized in the vicinity of the plant, where it has the advantage of freight rates over competitive products such as linseed oil cake and cotton seed meal. The other by-product is carbon dioxide. Along with each gallon of alcohol, about 4.5 lb of CO_2 is easily recoverable. At the present time most of it is obtained from wells, as a by-product in the production of lime, and by burning a sulphur-free coke and recovering the gas from the stack. There is at present a market for it in carbonated beverages and to a limited extent in dry ice. The production cost of dry ice, according to equipment manufacturers, is from ½ to ¾ cent per pound. The wholesale cost of the product in most areas is 2½ cents per pound. Considerable carbon dioxide as dry ice could no doubt be sold from industrial alcohol plants at a profit. The product has a temperature of −109 F. The refrigerating effect per pound is practically twice that of water ice. The commercial blocks weigh about 90 lb per cubic foot. In absorbing heat, dry ice passes directly from the solid to a gas. The gas has an inhibiting effect on bacterial and mold growth. These properties make it desirable for package refrigeration as well as truck and railway refrigeration. In the general field of refrigeration, especially package refrigeration, valuable research work could be done that would increase the use of dry ice and aid the distribution of perishable products.

Several additional uses for carbon dioxide have been proposed. One of interest to agriculture is its use with certain insecticides. While carbon dioxide is not in itself an insecticide, it stimulates respiration. When applied with an secticide such as ethylene oxide, the carbon dioxide is said to cause the insect to breathe vigorously and inhale the insecticide more promptly.

Profitable by-products other than distillers grain and carbon dioxide are a possibility with some raw materials. In some localities where sorghums are grown there is a preference for the so-called sweet sorghums. They make better ensilage than most grain sorghums and there is less difficulty with birds devouring the grain from the head. The seed tastes bitter due to the tannic acid that it contains. Feeders are reluctant to buy this seed due to its unpalatibility. Alcohol manufacturers have refused to buy it in large amounts because the tannic acid combines with iron while passing through the system and discolors the distillers grain. Tannic acid is now quoted on chemical markets at 40 cents per pound in large quantities. It already enjoys a very large market in the tanning and chemical industry. Practically all our requirements are imported. It seems that research on the recovery of tannic acid from the seed of such sorghum grain, preparatory to making alcohol, would be amply justified. This would open the market for that grain and might materially contribute to lowering the sale price of alcohol.

Of greatest importance is the utilization of the alcohol. Ethyl or grain alcohol is the starting point for many chemicals of industrial importance. The motor fuel market is extensive and the use of a 5 or 10 per cent alcohol in all the motor fuel used in the country probably would overshadow all other uses of alcohol. A national 10 per cent alcohol blend would utilize the starch from 800,000,000 bu of grain. This is indeed a large market. The desirability of such an additional market is beyond any question. A question naturally arises regarding the quality and cost of an alcohol-blended fuel. It is readily shown by tests that alcohol will raise the antiknock value of fuel to which it is added. Antiknock materials are necessary in gasolines used in the more efficient high-compression engines. It may be used by itself as an antiknock agent or in combination with organometallic compounds. In most cases its presence magnifies the effect of organometallic antiknock agents. There is produced at the present time a large quantity of straight-run gasoline of excellent quality except for octane number. By using either alcohol alone or combinations of alcohol and organometallic compounds, these fuels are easily built up to present premium octane grades and then could be used in our present highest compression engines. It is also interesting that some organometallic compounds that cannot be used for lack of solubility or other reasons in gasoline may successfully be used in a 5 or 10 per cent blend of alcohol and gasoline. Since the amount of organometallic compounds that may be added to motor fuel to produce antiknock effect is naturally limited, alcohol furnishes a means of producing higher octane fuels than are now available. This makes possible the use of higher compression ratios and consequently greater efficiencies. On a test run conducted by Mr. Champer and myself between Atchison, Kan., and Oklahoma City, Okla., a Plymouth automobile was fitted with an "export cylinder head". The compression was still further raised by planing down the head to give a displacement ratio of 8.5 to 1. The car was driven from 50 to 85 mph. The fuel used was a regular leaded gasoline to which 10 per cent anhydrous ethyl alcohol was added. For the entire trip the car travelled 28 mi per gal of fuel. Equipped in the regular way and using regular gasoline, this car averaged 17 mi per gallon. Another desirable feature of an alcohol blend is reduced oil consumption. While on a new motor oil consumption is small, it becomes a considerable factor as engine wear sets in.

In the final analysis a new fuel must cost no more per unit of work done. Alcohol must sell at a price higher than the present refinery price of petroleum fuel if a fair price is to be paid to the farmer for the raw material. However, by using alcohol in small amounts added to gasoline as a means of improving the quality of the product, a much higher price can be justified.

Ground Water Resources

(Continued from page 264)

6 A gradual rise, due to recharge, and smoothing out of the ground water surface occurs through the winter and spring months preceding the pumping season.

SUMMARY

1 A 10-year study of the ground water conditions in the Grand Prairie of Arkansas has been conducted by the University of Arkansas college of agriculture in cooperation with other agencies.

2 The irrigation water requirement during the past 10 years amounted to approximately 20 acre-inches per year, on an average of 124,000 acres of rice per year, 90 per cent of which was pumped from the Pleistocene sands.

3 The withdrawal of water has resulted in a lowering of the ground water by an average of 0.8 ft per year; however, the decline varies with seasonal rainfall, acreage, and location.

4 A continuous chart record affords evidence of a gradual and persistent decline of the ground water level, and shows annual, seasonal, and daily fluctuations.

5 It is evident that under present conditions the safe yield of the Pleistocene sands is being exceeded each year. Additional research study is under way to determine the safe yield and the possibility of developing economical surface supplies of irrigation water.

A Study of Temperatures Under Sheet Steel Roofs

By Henry Giese, W. D. Scoates and N. C. Ives

FOR many years the agricultural engineering section of the Iowa Agricultural Experiment Station has carried research projects relating to problems of farm housing. Believing that housing can be done successfully only when materials are used correctly, a large portion of the research has been directed specifically toward improvements in the use of materials.

On numerous occasions the limited funds available to the experiment station have been supplemented by grants from organizations and individuals for the purpose of carrying on projects of public interest but which otherwise could not be adequately financed. This arrangement has been attractive to industry because of the possibilities of utilizing facilities available at the college and because of the prestige attached to research done at publicly supported institutions.

On July 1, 1937, such an arrangement became operative between the Iowa Agricultural Experiment Station and the Republic Steel Corporation, for the purpose of initiating a study to investigate past and present uses of steel in farm construction, to find wherein they may have failed to produce satisfactory results, and to attempt to devise improvements which will result in a better performance. In some instances, perhaps, failure is the result of poor application, necessitating a program of education. In others, certain changes may prove advisable either to improve performance directly or to increase the probability of more skilled application. Or it may be that new products should be developed to meet needs not now taken care of. Farm uses offer great possibilities in standardized construction, which, in turn make for economies as a result of large-scale production.

Considerable time at the outset of any research program may profitably be devoted to a study of the problem. The

Released for first publication in AGRICULTURAL ENGINEERING. Mr. Giese (Fellow A.S.A.E.) is professor of agricultural engineering, and Mr. Scoates (Jr. Mem. A.S.A.E.) and Mr. Ives (Jr. Mem. A.S.A.E.) were research fellows in agricultural engineering at Iowa State College who assisted in this project.

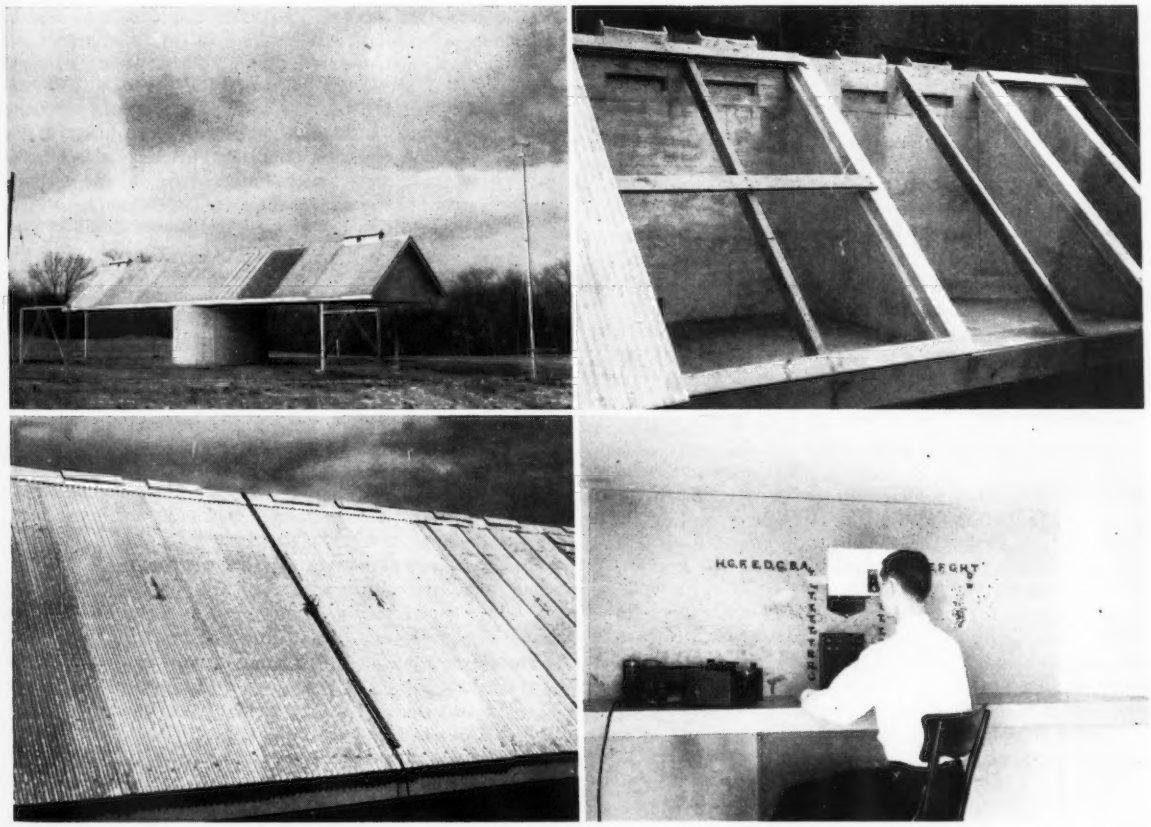

FIG. 1 (UPPER LEFT) APPARATUS USED IN OBSERVING TEMPERATURES UNDER VARIOUS ROOF SECTIONS, SHOWING SECTIONS OF ROOFS TESTED, CIRCULAR INSTRUMENT ROOM DEVISED TO PERMIT ROTATION, AND ANEMOMETER TOWER. FIG. 2 (UPPER RIGHT) COMPARTMENTS UNDER CONSTRUCTION WITH ENTRANCE HATCHES AND FLOOR IN PLACE. FIG. 3 (LOWER LEFT) CLOSE-UP OF ROOF SECTION SHOWING THERMOCOUPLES AND WIRE ANEMOMETER. FIG. 4 (LOWER RIGHT) INTERIOR OF OBSERVATION ROOM

requirements placed upon a material and its potential ability to meet them must be known before structural uses can be satisfactorily developed. Many publications relating to farm uses of steel were examined. A number of field trips were taken to secure a better idea of the extent to which steel products find application in farm buildings and the attitude of owners and merchants toward the use of steel.

As this study was dedicated to a solution of problems, and not to eulogize performance, this presentation deals primarily with (1) problems found to be pertinent, (2) the analysis of a proposed method of solution, and (3) the description of apparatus now in use for that purpose. Conclusions will be presented in subsequent reports as various phases of the investigation are completed. While several pertinent problems developed as a result of the field trips, one in particular related to a rather prevalent belief that buildings roofed with steel are excessively hot in summer and cold in winter. Whether this is actually true, and if so to what degree, was neither apparent nor obtainable from any literature consulted.

The first undertaking on this project, then, was to determine to what extent the roof material does absorb available solar heat, what portion finds its way into the building, and how much is reflected. If found desirable, what auxiliary means may be employed to obtain the advantages of steel and at the same time remedy any determined disadvantages?

A specially designed test house was constructed for the investigation. As illustrated in Fig. 1, it consists of testing roof, instrument room in the center, circular concrete foundation, and end supports or wind braces. This house is so constructed that it can be turned on the foundation through an arc of 90 deg for orientation studies. The original apparatus comprised sixteen testing compartments (two sets of eight) and four end compartments, one-half on each side of a center division or beam which serves as a carrying structural member and also an insulating partition between the two sides of testing roof. Cornstalk insulation was enclosed between the two sheets of ¼-in plywood applied to either side of the 2x4 frame with nails and casein glue. The triangular divisions between the compartments were fabricated in a like manner. Five inches of cornstalk insulation were used on the floor. The construction is shown in Fig. 2.

The foundation is a reinforced concrete ring 9 ft, 9¼ in in diameter and 6 in thick, with footing extending below the frost line. On this foundation is a steel carriage with eight rollers that support the building and instrument room floor.

Roofs selected for test included a number of types commonly used for farm structures. Comparisons are being made between corrugated, galvanized steel roofing with its greater surface area, and the V-crimp type of roofing. Both open and tight roof decks, various applications of insulation, and a wood-shingle roof are also included. All steel sheets used were 28-gage galvanized.

To analyze further the properties of the roof sections covered with galvanized sheet steel roofing, two extra roof sections, one on each end, were added to the original test house to incorporate the feature of ventilation within the roof section.

Thermocouples were placed at various points in each roof section (Fig. 3), and in addition one was placed 12 in and one 24 in below the surface for the purpose of obtaining room temperatures in each compartment.

Three instruments and their circuits were used on this project. For temperature readings of the thermocouples a Leeds and Northrup moving coil reflective type galvanometer, with its scale calibrated directly in degrees Fahrenheit,

FIG. 5 EPPLEY PYRHELIOMETER USED IN MEASURING INTENSITY OF SOLAR RADIATION, PLACED ON 100 FT TOWER ABOVE OBSTRUCTIONS AND EQUIPPED WITH COVER WHICH CAN BE CLOSED TO PROTECT INSTRUMENT FROM HAIL

with a range of −40 to +210, was employed and read by telescope. A constantan wire common to all thermocouple circuits in each compartment reduced the wiring cost and increased the speed of readings. Because iron and constantan wire are used for thermocouples, two cold junctions, iron copper and constantan copper were required in the ice bottle. As the binding post and other terminals were of brass or copper, copper was chosen as the wiring material on the galvanometer side of these cold junctions to prevent any thermoelectric effects caused by the junctions of two dissimilar metals at different temperatures. A Leeds and Northrup potentiometer, with a thermocouple wire anemometer made by the American Instrument Company, was used to secure wind velocity readings. This equipment was, however, later replaced with a standard three-cup anemometer with indicator.

To obtain a record of the intensity of the total radiation impinging upon a horizontal surface, an Eppley pyrheliometer with a Leeds and Northrup recording potentiometer were employed. The Eppley pyrheliometer (Fig. 5) consists of a thermopile hermetically sealed in a glass bulb which has been thoroughly dried out and partly evacuated. The thermopile consists of ten couples of gold-palladium and platinum-rhodium wire. Alternate junctions are fastened to rings coated with soot and magnesium oxide. These blackened and whitened surfaces absorb long-wave radiation equally well, but the magnesium oxide has a high coefficient of reflection for radiation having the wave length of solar radiation. Therefore, when exposed to solar radiation, the two rings of this pyrheliometer develop a marked temperature difference and the resulting current measured by the potentiometer indicates the intensity of solar radiation. To date only total radiation, direct plus diffuse, striking a horizontal surface, has been measured. Fig. 6 shows typical pyrheliometer charts for six days encountered thus far. The essential information is indicated on each chart. The scale reading is from 0 to 3 millivolts, as shown, and the curves indicate directly the emf (electromagnetic

potential) produced by the thermopiles, which values must be divided by the constant 1.51 to obtain values in the units g-cal/min^{-1}/cm^{-2}. These are the values for a horizontal surface and since in this study the normal intensities for other plane surfaces facing the cardinal points of the compass are desired, it is necessary to find the components of these values for other nonhorizontal surfaces. To do this demands a careful and rather lengthy procedure. From the pyrheliometer charts it is quite apparent that on a clear day, due to decrease in intensity and length of day, the solar radiation in winter is very much less than in summer. This difference is further increased by the cloudy days. The use of the pyrheliometer not only makes possible a more specific and quantitative analysis of the results obtained, but also to predict performance of the various roof sections in other locations providing, of course, that pyrheliometer records are available.

The problem changes from one of heat gain in summer to one of heat loss in winter. To measure this, each compartment was furnished with a heating unit to (1) study the characteristics of the roof sections for typical winter conditions which exist for heated buildings and to (2) find the absolute resistance to heat flow for each of the ten roof sections.

To design the heating units, the amount of heat lost through the floor and roof of each compartment for the desired outside and inside air temperature difference was determined approximately through the use of conductivity coefficients as obtained from the 1937 A.S.H.V.E. guide.

Two possible methods could be followed in supplying this heat to produce data easily interpretable.

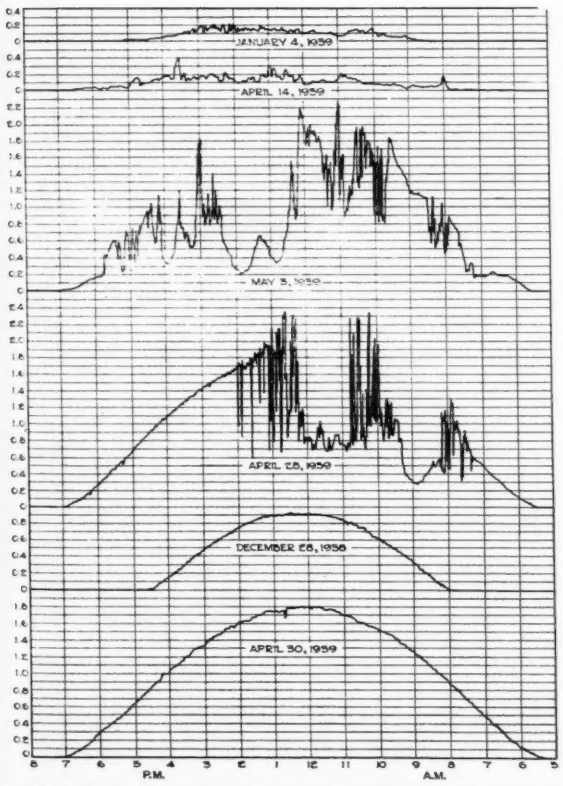

FIG. 6 TYPICAL PYRHELIOMETER CHARTS SHOWING WIDE VARIATIONS IN INTENSITY OF SOLAR RADIATION DUE TO SEASONAL POSITION OF THE SUN AND TO OBSTRUCTION BY CLOUDS

1 An equal amount of a known quantity of heat could be supplied to each compartment. The resulting compartment temperatures would then show directly the approximate relative resistance of the roof sections. This indication would not be entirely accurate because different compartments air temperatures would produce different amounts of heat losses in and out of the compartments.

2 The heat could be apportioned to maintain all the compartments at the same temperature. This would approach the ideal in studying the heat flow characteristics of the roof sections, because (a) it would provide for equal mean temperatures of the roof section, (b) the relative amount of heat inputs would indicate directly and accurately the relative resistance of the roof sections, (c) the heat losses to the outside air through the floor of the compartments would be the same, and (d) there would be no heat transfer beween the compartments. While the design and construction of a device to maintain a constant temperature within the enclosed air space is entirely possible, the practical problems involved in providing twenty such units resulted in the use of the first-named method. Since electrical energy is easily converted into measurable amounts of heat, electricity was used to supply the artificial heat to each compartment.

Readings are taken hourly over a 24-hr testing period with the test sections placed to get either a north-south or east-west exposure.

The following relationships are being calculated from the observations taken:

1 Solar heat falling on roof surfaces ½ pitch, north, south, east, and west orientations.
2 Part of solar radiation absorbed by the roof.
3 Temperature gradients through sections.
4 Experimental conductivity coefficients for roof sections.
5 The effect of air currents upon surface and compartment temperatures.
6 The effect of rain upon surface and compartment temperatures.
7 Maximum surface and compartment temperatures.
8 The range of surface and compartment temperatures.
9 The rates of increase or decrease in surface and compartment temperatures under various conditions (Fig. 7).

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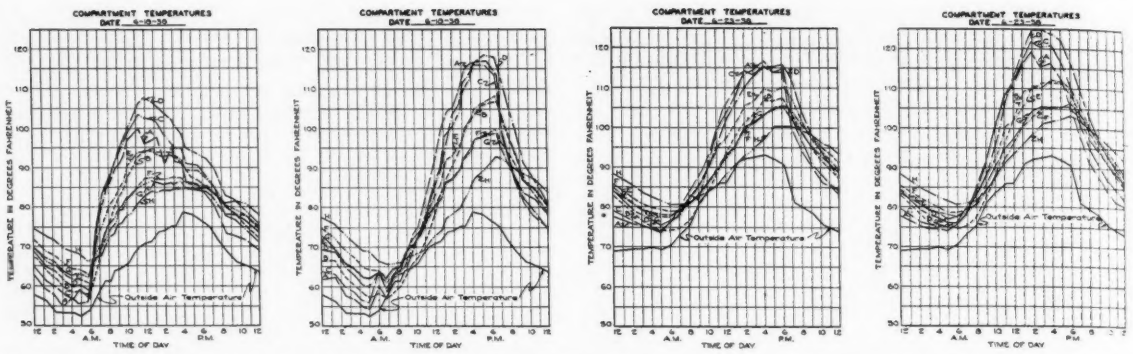

FIG. 7 COMPARTMENT TEMPERATURE DIAGRAMS SHOWING COMPARISON WITH OUTSIDE AND FLUCTUATION DURING A 24-HR PERIOD: *a*, EAST EXPOSURE; AND *b*, WEST EXPOSURE, JUNE 18, 1938; *c*, NORTH EXPOSURE, AND *d*, SOUTH EXPOSURE, JUNE 23, 1938

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Engineer as Citizen and Policy Maker

THE engineer must get the habit of seeing himself, not just as a technical specialist, but also as a citizen and as a policy-determining member of the community. Whether an engineer works for the public or for private industry, he should do more than echo the views of his employer. He should not be a "yes" man or a shadow of those on whom he relies for a living.

It is not only in *public* work that the engineer is under pressure to reflect the views of his employer. I believe it may be a valid criticism of engineers as of professional men in general that from a spirit of loyalty they tend sometimes uncritically to adopt the views of their employers, rather than to develop their own social philosophies in a responsible, independent and objective manner.

Before the engineer can be a substantial force in a democracy he must have a mind of his own. He must have worked for and achieved a social philosophy which is not just a reflection of that of his last employer. Until that independence of outlook is achieved, he is not yet in fact a part of democratic government. He cannot expect to be a large factor in policy-making decisions, except purely as a technician. He may pass judgment on the technical feasibility of a project, but whether or not it is in the public interest will be considered none of his business.

Given development of self-respecting judgment and social philosophy, there is another step engineers can take to make themselves a part of the democratic process. The individual engineer, whether his employer is the government or a private company, is in a very vulnerable position. His professional standards require integrity of judgment, and such integrity by and large has been characteristic of his profession. But the days of the independent practicing engineer are largely past. He now works for an employer, and he takes orders.—*A. E. Morgan.*

Supplementary Irrigation on the Atlantic Coast

By F. E. Staebner

AFTER almost any marked advance it is desirable to review the gains so far attained. Supplementary irrigation is at such a point at the moment, and it is believed that a review of the situation as it exists along the Atlantic Coast will be of interest.

In that area the comparatively recently developed type of portable sprinkling irrigation equipment, consisting of light-weight galvanized iron pipe equipped with quick-assembling and disassembling joints and revolving sprinklers, is by all means the most popular and its relative popularity over the last few years seems to hold whether it be judged by the number of systems installed or the amount of money invested. Its outstanding advantages are (1) comparatively low cost per acre for an irrigation system that gives good control of distribution and (2) the ability to get all the pipes and fittings off the field and out of the way when desired. These advantages have undoubtedly placed this type of equipment in a strong relative position. Its comparative weakness is that it requires more labor at irrigating time than some other systems now in use. The eastern farmer, rather naturally probably, has never taken kindly to the thought of adding to his already heavy growing-season schedule another occasionally used, labor-consuming practice.

For the relatively few localities in which it may be used, subirrigation is probably even more popular than the portable sprinkling irrigation referred to above. In fact, the mental appeal of subirrigation seems to be universal. With a copious supply of gravity water of good quality on land that has a porous top soil underlain at a suitable depth by an impervious layer and a surface that is only slightly sloping with a uniform slope in one direction, the subirrigation method is about ideal. Although a porous top soil is usually considered to be necessary for successful use of this method, it is known that a few systems may be found where the top soil is too heavy to come under that classification. In those cases an even heavier subsoil is probably present and the tile lines have been placed closer together than normal. From the standpoint of the Atlantic Coast farmer the subirrigation method has two marked features that are desirable, namely, there is little in the way of field obstructions to hamper cultivation and it requires almost no labor to irrigate.

The overhead pipe type of sprinkling irrigation is thoroughly established. Irrigation is accomplished with very little labor. Good distribution of water may be obtained with reasonably good handling and the farmers have confidence in it. The lines of supporting posts in the field are annoying but endurable. High cost of investment is its most serious drawback. If it were not for the high cost it seems likely that the majority of prospective irrigators in the Atlantic Coast states where subirrigation cannot be used would adopt the overhead pipe system.

Portable pipe systems of surface irrigation are fairly popular right now. Both the quick-assembling and disassembling light weight iron pipe mentioned above for sprinkling irrigation and the better grades of the older type of slip-joint pipe with the friction joints are used. The cruder, less efficient type of improvised systems made up of the very light weight locally made galvanized sheet iron and rain-leader or downspout pipes seem to be passing out.

Surface systems and low-pressure pipe systems for surface distribution seem not to be in the limelight right now.

A momentary consideration of the future leads to the conclusion that, in the future as well as in the past, cost is the greatest deterrent to wider use of irrigation in the humid areas. The fact that the occasional dry spells of indeterminate duration encountered in different parts of the humid region are actual deterrents to crop production seems to be quite generally recognized. This is supported by a large part of the existing experimental evidence and by the satisfactory results achieved by the majority of the farmers who have practiced irrigation.

A field for the extension of irrigation may be found in the southern Atlantic Coast states of South Carolina and Georgia. Without waiting for land to be withdrawn from the growing of cotton and turned over to the growing of other crops, when the need for supplemental irrigation in that area may be expected to become more definitely apparent, the need for the irrigation of gardens is with us right now. The problems in the way of filling that need, however, are serious. It is usually difficult in that area to get water in satisfactory quantity from wells, and it must commonly be pumped through a long pipe line and raised many feet in elevation if taken from a surface source. In some places storage reservoirs can be constructed in favorably located stream beds, but the possibility is not universal. It

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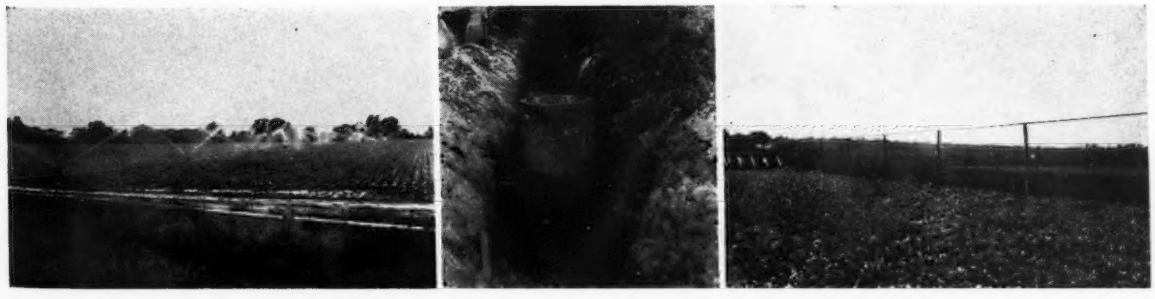

(LEFT) PORTABLE SPRINKLER IRRIGATION EQUIPMENT IN OPERATION. (CENTER) A CLAY TILE SUBIRRIGATION SYSTEM UNDER CONSTRUCTON. (RIGHT) AN OVERHEAD PIPE IRRIGATION INSTALLATION

is, moreover, expensive to put down a deep well or to build a long pipe line. It is often expensive to construct a reservoir, but when one can be constructed by the farm workers without much direct cash outlay, it may be the most feasible way to obtain a water supply.

Owing to the unimportance of the farm garden in the mind of the average eastern farmer, it is likely that any widely used method of garden irrigation that may be adopted must be one that requires very little labor. Otherwise the competitive demand on the farmer's time for the handling of cash crops will result in failure to water the garden when it needs watering even with the equipment at hand to do it.

In spite of the fact that there appears to be a rather definite need for the irrigation of gardens in the southeastern corner of the United States, and for a considerable distance northward along the Atlantic seaboard, it is probable that there are local differences in the extent of the need. Incidental observations elsewhere have shown pronounced differences in the irrigation need of different localities even though those localities may have nearly the same amount of average annual rainfall and may be separated by comparatively few miles. Enough such incidental observations have been made to warrant the belief that such variations may exist quite generally in the humid states. We do not, however, now have any ready means of determining the need, or even the relative need for irrigation in different localities.

Although it is something of a digression from the stated subject of this paper, I want to mention an effort now being made to classify data on the relative irrigation needs of the different localities.

The relative irrigation needs of the different localities, in so far as rainfall governs that need, is as far as we feel justified in going at the present time. The more complex problems of soil and slope conditions, of advancing seasonal conditions, of crops that may retard runoff and so increase infiltration, and of different cultivation and tilth conditions, etc., are being avoided entirely. Our only hope is, for each locality, an indication of the average condition.

Even with all the interconnected complexities brushed aside and the problems reduced to one involving rainfall alone, there are many opportunities for disagreement with our procedure. However, we welcome suggestions, and I am here outlining our methods in order to give an opportunity to make them.

In addition to limiting the field to average rainfall, we are further limiting the applicability of our study to such crops as we may assume will, in a ten-day period with the aid of surface evaporation, withdraw one inch in depth of moisture from the soil. In other words, the viewpoint with which we are starting is that one inch of precipitation must be received in every ten-day period to secure most efficient crop growth for such crops as are considered. If less than one inch has been received in any ten-day period, we assume that a retardation in crop growth occurs, and that if more than one inch is received no additional benefit is obtained by irrigation.

For a reasonable number of well-distributed localities in each state for which a sufficient number of years of rainfall record are available, we expect to determine an irrigation need index on this one inch in ten-day basis. It will, we hope, as stated for any locality, more or less express the average number of inches depth of water that should annually be supplied to the ground around the plant roots to maintain the one-inch depth in ten days requirement. We believe it will be comparative from locality to locality however much different irrigation designers may feel the figures should be adjusted upwards or downwards. It will, of course, make no allowance for waste or non-uniform distribution of irrigation water.

To determine it we are at present determining, for each of the accepted rainfall stations for each day of the growing season, the total amount of rain that has fallen on the ten-day period including and ending with that day. This figure we call the ten-day precipitation index. Each day, when the ten-day precipitation index is 1.00 or more, is assumed to be a day of sufficient water supply. Each day when the ten-day precipitation index is less than 1.00, we assume to be a day of growth retardation, the extent of the retardation being measured by the extent to which that index is less than 1.00. Although somewhat of an exaggeration, we are calling those days *(Continued on page 276)*

FIRST STEP—DERIVATION OF THE PRECIPITATION INDEX

Date		Precipitation	10-day Precipitation Index
April	22	0.07	
	23	Average date of last killing frost	
	24		
	25		
	26		
	27		
	28		
	29		
	30		
May	1		
	2		
	3	0.25	
	4	0.22	
	5	0.03	
	6		
	7	First day of irrigation season	0.50
	8	0.01	0.51
	9	0.24	0.75
	10		0.75
	11	0.06	0.81
	12	0.05	0.86
	13	0.01	0.62
	14		0.40
	15		0.37
	16		0.37
	17		0.37
	18	1.07	1.43
	19	2.77	3.96
	20		3.96
	21	0.05	3.95
	22		3.90
	23		3.89
	24	0.10	3.99
	25	0.93	4.92
	26		4.92
	27		4.92
	28		3.85
	29		1.08
	30		1.08
	31		1.03
June	1		1.05
	2	0.38	1.41
	3		1.31
	4		0.38
	5		0.38
	6		0.38

SECOND STEP—DERIVATION OF IRRIGATION INDEX

Average ten-day dry day precipitation	0.36 in
Average ten-day dry day deficiency	0.64 in
Average daily deficiency	0.064 in
Average annual number of dry days	96
Irrigation index (0.064 x 96)	6.14

Watershed and Hydrologic Studies on the Blacklands Experimental Watershed

By Ralph W. Baird

DURING THE early part of 1936 considerable time, thought, and study were expended in the selection of an area suitable for the studies of the type planned under the program of the watershed and hydrologic studies section[1] of the research division of the U. S. Soil Conservation Service. This work of selection was largely that of D. B. Krimgold of the Washington office of this section. An area known locally as the Brushy Creek Watershed was finally selected. This watershed of about 5600 acres is in an area considered typical of the Blacklands of Texas, located about 15 miles southeast of Waco, Texas.

In Mr. Ramser's earlier paper on the subject, the primary objectives set up for these studies were:

1 To determine the effect of erosion control practices and land use upon the conservation of water for agricultural purposes, such as irrigation and domestic farm supplies, and for public utility purposes, such as water power and urban water supplies.

2 To determine the effect of erosion control practices and land use upon the control of floods that destroy crops, damage soil fertility on agricultural bottom lands, and cause damage to or destruction of municipal property.

3 To determine the rates and amounts of runoff and eroded soil material from rains of different amounts and intensities, for use in the economic design of erosion control and flood control structures. This information will also be of value in determining to what extent eroded material can be prevented from entering and reducing the capacity of drainage channels and reservoirs, by the application of proper land use and erosion control practices.

In general the topography of the area selected is gently rolling with the average slope being from two to three per cent. Small areas are not well defined and the larger streams have broad flat bottoms which are frequently overflowed. The soils of the area are considered typical of the Blacklands of Texas, soils of the Houston series predominating. Generally these soils are heavy clay calcareous soils with a high content of colloids. The geology of the area is fairly uniform, the underlying material being a fine calcareous marl. There is one thin layer of chalk which outcrops in the watershed.

The area is intensively cultivated, about 80 per cent of the area being in cultivation, and prior to the control of cotton acreages about 70 per cent of the cultivated land was planted to cotton. Corn, oats, and sorghum crops are the other principal crops.

Development of the detailed plans for these studies has been largely the work of C. E. Ramser, H. R. Leach, and W. U. Garstka, of the Washington office, and D. S. Jenkins, C. W. Lauritzen, H. R. Blank, and G. E. Byars of the Waco staff.

The Brushy Creek area was selected as a suitable location, the general plan being that runoff and other measurements would be made from the various subareas of this drainage area. Erosion control practices and improved land use would be established in cooperation with the private land owners, preferably after several years of records have been obtained under prevailing practices. Knowing that some of the work that should be done could not be done on private land, about 840 acres of land were purchased for the more intensive studies.

The purchased land consists primarily of two rather similar drainage areas of about 300 acres each, each of which can be divided into a number of smaller natural areas. As the federal government has complete control of

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Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 1, 1938. Mr. Baird (Mem. A.S.A.E.) is hydraulic engineer, Soil Conservation Service, U. S. Department of Agriculture, and project supervisor, Blacklands Experimental Watershed.

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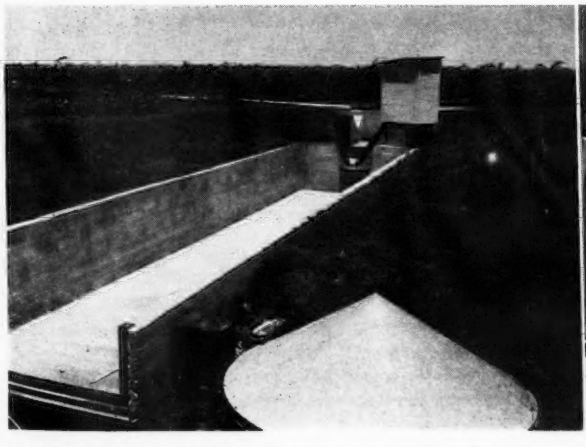

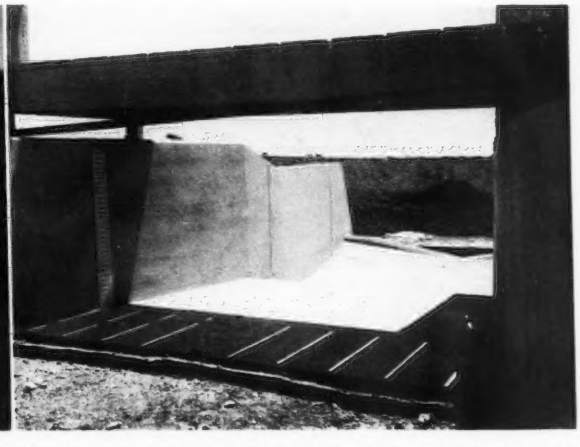

Fig. 1 (Left) Type H-3 flume, Ramser silt sampler, gutters, and recorder house at 3-acre watershed No. 18. Fig. 2 (Right) Parshall 6-ft flume with 1 to 5 slope Columbus type weir in recovery section at watershed Y-10

these areas, it was planned that both would be continued in the prevailing land-use practice for a preliminary period of several years to observe the relative behavior of the areas when cropping conditions are similar. After this preliminary period, one of these watersheds will have established upon it an improved, coordinated erosion control program, while the other will be maintained in its present land use. Any appreciable change in the relative behavior of the two watersheds or their subdivisions would indicate the value of the erosion control program.

With this general plan, more detailed plans were prepared for the construction of the necessary measuring equipment and the collection of records.

The collection of meteorological records is of primary importance. Recording and standard rain gages have been installed at rather regular intervals over both the privately owned and government-owned land. At the present time there are 90 precipitation stations, each consisting of one standard rain gage, and 10 stations, each consisting of one recorder and one standard rain gage, on private lands in the Brushy Creek Watershed. On the government-owned land there are 22 precipitation stations with recording gages. Other meteorological records of value in the interpretation of hydrologic data are those of temperature, evaporation, wind movement, relative humidity, and barometric pressure. These records are obtained at selected locations. On October 1, 1938 a central meteorological station was put in operation, where records of precipitation, temperature, wind movement, evaporation, relative humidity, barometric pressure, and sunshine duration are obtained. In most cases it has seemed desirable that precipitation as measured by a single recording rain gage be used in connection with runoff computations from areas of twenty acres or less, but for larger areas records from several rain gages will be used.

A large portion of the work at this project is the collection and analyses of data on surface runoff, and such is stated as one of the major objectives. Surface runoff is also one of the criteria of the effectiveness of erosion control practices and therefore is a part of the information desired as the other major objectives.

Runoff records are now being obtained from areas ranging in size from ¼ acre to 5600 acres. On areas of about 200 acres or less, a calibrated flume together with a stage recorder is used to determine rates and amounts of runoff. For areas of ¼ acre to 3 acres, a type H flume of the desired size is used (Fig. 1). As compared to the Parshall flume, this flume has the advantage of greater change in stage for small changes in discharge at low flows. It also has advantages in that the rating is not seriously affected

TABLE 1. GAGING STATIONS AT THE BLACKLANDS EXPERIMENTAL WATERSHED NEAR WACO, TEXAS

Station No.	Type of control	Drainage area acres	Location	Date record started
A	10-ft Parshall flume, Columbus weir low-water control	42.5	Stream, Brushy Creek, private	May 13, 1938
C	Columbus weir, current meter	533	" "	Dec. 11, 1937
D	" "	1091	" "	Nov. 12, 1937
G	" "	4220	" "	Nov. 6, 1937
J	" "	5690	" "	June 24, 1937
Y	" "	312	Government-owned land, tributary to Brushy Creek. Erosion control practices to be established later	April 22, 1937
Y-2	15-ft Parshall flume, Columbus weir low-water control	134.4		Oct. 4, 1938
Y-4	10-ft Parshall flume, Columbus weir low-water control	80.6	" "	Oct. 5, 1938
Y-6	6-ft Parshall flume, Columbus weir low-water control	20.0	" "	Sept. 16, 1938
Y-7	" "	40.1	" "	Not complete
Y-8	" "	19.9	" "	Not complete
Y-10	" "	20.1	" "	July 12, 1938
W-1	15-ft Parshall flume, Columbus weir low-water control	175.8	Government-owned land, not a tributary to Brushy Creek	June 22, 1937
W-2	" "	130.9	" "	June 23, 1937
W-6	6-ft Parshall flume, Columbus weir low-water control	40.6	" "	Not complete
W-8	" "	40.5	" "	July 11, 1938
W-10	" "	19.9	" "	July 12, 1938
SW-2	H-3 flume, Ramser silt sampler	2.70	Government-owned land	April 1, 1938
SW-3	" "	3.05	" "	Not complete
SW-5	" "	3.03	" "	Oct. 1, 1938
SW-6	" "	3.02	" "	Oct. 26, 1938
SW-7	" "	3.12	" "	March 9, 1938
SW-11	" "	3.16	" "	March 2, 1938
SW-12	" "	3.00	" "	Dec. 15, 1937
SW-13	" "	3.10	" "	March 8, 1938
SW-14	" "	Not built	" "	
SW-16	2-ft Parshall flume, Ramser silt sampler	3.21	" "	Sept. 24, 1937
SW-17	H-3 flume, Ramser silt sampler	Not built	" "	
SW-18	" "	3.01	" "	April 2, 1938
3% Plot 1	H-1 flume, Ramser silt sampler	.243	" "	June 8, 1938
3% Plot 2	" "	.243	" "	June 7, 1938
3% Plot 3	" "	.243	" "	June 7, 1938
3% Plot 4	" "	.243	" "	June 7, 1938

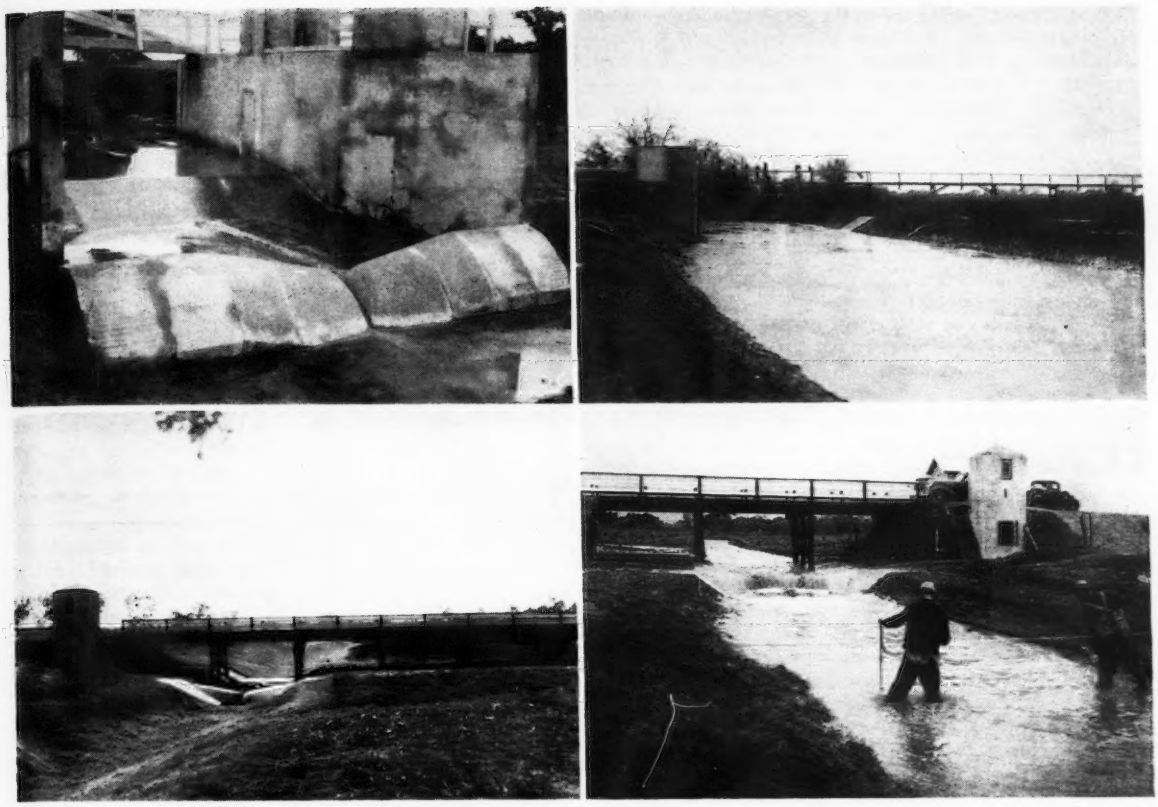

Fig. 3 (Upper left) Parshall 15-ft flume with deep notch Columbus type weir in recovery section at watershed W-1. Fig. 4 (Upper right) View at gaging station J during runoff period January 23, 1938; gage height is approximately 11 ft. Lower water control used is similar to that shown in Fig. 5. Fig. 5 (Lower left) View of gaging station Y showing deep-notch Columbus type weir low-water control, concrete recorder shelter and highway bridge which has catwalk on upstream side from which current meter measurements are made. Fig. 6 (Lower right) View of gaging station D during runoff period March 27, 1938; gage height approximately 1.4 ft. Low-water control is similar to that shown in Fig. 5

by a considerable amount of submergence, and it is not sensitive to slight errors in setting.

For areas of from 20 to 180 acres, a modified Parshall flume is used to measure surface runoff (Fig. 2). The upper part of this flume is identical with the standard Parshall flume, but it has a Columbus type weir in place of the regular recovery section. Because of its shape the Columbus type weir makes possible a relatively accurate measurement of low flows and does not readily clog with trash. On some of the first flumes constructed at this project the deep notch Columbus weir was used (Fig. 3). It was soon found that this deep notch weir was more sensitive than required and on the later flume construction a Columbus weir with a 1 to 5 slope was used (Fig. 2).

At the larger stations (Figs. 4 and 5) the Columbus type weir is used for the determination of low flows, but each of these stations will have a rating curve developed for it by making discharge measurements. The standard and low-velocity Price current meters are being used in making these discharge measurements. Due largely to the flat slopes in the stream channels at the larger stations, some difficulties have been experienced, but it is believed that these stations in their present condition with a considerable number of current meter measurements will give quite accurate records.

The size and various characteristics of the stations planned or in operation at this project are shown in Table 1.

Records will be obtained from the stations along the main stream of Brushy Creek (stations A, C, D, G, and J) for a period under prevailing practices, and as erosion control practices and improved land use are developed upon these areas the records should reflect the effectiveness of these practices as these records can be compared with the untreated area, W, throughout the life of the study and with watershed Y as an untreated area for a period prior to the establishment of erosion control practices and later with watershed Y as an improved area.

The layout of the work in watersheds Y and W is such that records will be available from similar size areas, one or more of which will have on it improved practices and one of which will be continued in prevailing practice. The range in size of these areas is as follows:

Watershed Y, Future improved practices		Watershed W, Continued prevailing practices	
Station No.	Area, acres	Station No.	Area, acres
Y	312	W1 + W2	306.7
Y-2	134.4	W-2	130.9
Y-4	80.6	W2 – W-8	90.4
Y-7	40.1	W-6	40.6
		W-8	40.5
Y-6	20.0		
Y-8	19.9	W-10	19.9
Y-10	20.1		

The 20-acre areas listed in the above tabulation are 100 per cent cultivated areas with a crop distribution of very closely 50 per cent cotton, 25 per cent corn, and 25 per cent oats. The areas larger than 20 acres include small acreages of other crops, pasture, meadow land, building sites, etc. In all cases an attempt has been made to keep the same percentage of crops in areas of approximately the same size.

All except one of the 3-acre areas are cultivated and all of any area is in the same crop any particular year. The one exception is an area of native meadow land with an average slope of 3½ per cent. The cultivated areas are divided into three general groups depending upon their slope. The larger group is in the intermediate slope group with slopes of about 2 per cent. There are six small watersheds in this group. There are also two small watersheds having a slope of about one per cent. There are three watersheds in the steeper group (about 3 per cent).

As shown by Table 1 there are four areas of 0.243 acre each on a 3 per cent slope. These four areas were very carefully selected for as near uniform slope and soil conditions as was possible. These areas are rectangular, 63 ft wide and 168 ft long, made of these dimensions to accommodate either 36 or 42-in rows either up and down or across the slope. They will be cultivated using a 4-yr rotation of cotton, corn, cotton, oats, beginning with each area in a different year of the rotation. This information should supplement that obtained from the 3-acre areas and may give some information which, with the various-sized larger drainage basins, will enable us to trace more logically the relation between size of area and runoff and soil losses. Also, because of the close similarity of these particular areas, they also offer an opportunity to study soil-moisture storage and depletion and the effect of this storage and depletion on surface runoff.

Soil losses from the 3-acre and the ¼-acre areas are measured by means of a Ramser silt sampler placed downstream from the type H flume. At the areas larger than 3 acres the trapping of eroded material is not feasible and it has been necessary to rely upon manually-collected silt samples at these various stations.

As soil moisture conditions are one of the important conditions affecting surface runoff, and also may be a measure of the effectiveness of conservation practices, considerable work on the study of soil moisture has been started. To this time our studies have been largely concerned with the development of a sampling procedure which will give a fairly accurate measure of the moisture content throughout the different parts of the soil profile. Since it is our desire to change moisture content to equivalent surface inches of water, it is necessary to know the volume weight of the soil, and since the volume weights of the soils of this area change appreciably with changes in moisture content, volume weight studies are an integral part of this work.

Infiltration studies are directly of value in determining the effectiveness of conservation practices, variations in different watersheds, and in different parts of the same watershed. To the present time our work has been limited to a few measurements made employing the Musgrave[2] technique, but it is expected that more extensive work with an artificial rainfall apparatus will be started soon. In the infiltration studies conducted at this project our major attempt will be to find the relation between the results obtained by these sampling methods on small areas with the results as determined by the measurement of precipitation on and runoff from larger natural areas.

Knowing that a major portion of the precipitation in this area is stored in the soil and then used by plants or lost, through evaporation and transpiration, some plans have been made to determine the amount of water passed into the atmosphere through evaporation and transpiration. No actual field work has yet been done at this project on this interesting phase of our investigations.

The geology of the area has a great effect upon its physical surface characteristics, soils, and underground water. In the preparation of the geologic map a large number of relatively shallow (15-35-ft) test holes were drilled. Many of these test holes have since been cased and are now in use as ground water observation wells. The ground water studies to date have been largely of an exploratory nature, but records are now being obtained from 157 wells by means of tape measurements and 19 water stage recorders have been installed on ground water wells. Recorder installations are being completed at additional wells as rapidly as possible.

To date only preliminary data have been obtained, but with most installations now in operation and with better facilities for other work being available, it is expected that some data will soon be available on surface runoff and soil losses from watersheds of different sizes and other characteristics; soil moisture conditions on selected areas; infiltration rates under different soil and cover conditions; and ground water conditions in various parts of the area.

[2]Musgrave, G. W. — The infiltration capacity of soils in relation to the control of surface runoff and erosion. Jour. Amer. Soc. Agron., 27-336-345, 1935.

Supplementary Irrigation on the Atlantic Coast

(Continued from page 272)

with a precipitation index of less than 1.00, dry days. The average precipitation index for all the dry days we consider to represent the average proportionate growth possibility for the moisture deficient time.

As our figures so far are based on ten-day intervals, one inch in ten days for the moisture requirement and a precipitation index based on a ten-day period, one-tenth of each of those figures becomes the corresponding daily figure or index. One-tenth, then, of the ten-day precipitation index, taken from 0.100 (1/10 of 1.00) in, then becomes the daily moisture deficiency if our basic assumption is correct. This figure for average daily moisture deficiency for the dry days multiplied by the average annual number of dry days gives the amount of water in inches depth necessary each year on the average to be supplied by irrigation in order to maintain the standard of one inch each ten days set up for the assumed requirement for efficient growth. This figure, as determined for each locality, we are taking as the irrigation index for that locality.

The growing season, as we are taking it, extends from 15 days after the average date of the last killing frost in spring to 15 days before the average date of the first killing frost in autumn for each locality. The investigation is being made by the Bureau of Agricultural Engineering in cooperation with the Weather Bureau and the Works Progress Administration.

Changes in the procedure, or even in the basic principle, are possible and an ultimate extension to bring in other ranges of estimated crop requirements are likely.

What Constitutes a Good Rural Electrification Extension Program

By M. M. Johns

CONSIDERED from a broad viewpoint, rural electrification is merely an integral part of our national, state, county, and community agricultural program. The agricultural leaders of our nation have acknowledged the fact that rural electrification is making important contributions to public health, to living standards, to home ownership, and to farming methods and income.

Due to accelerated activities in rural electrification for the past few years, it has been nearly impossible for the extension service to meet the demands made upon it with the limited trained personnel available. A number of states have been active in this work for some ten or twelve years, and although they have had one or two persons connected with their extension organization, they have found it impossible to meet the demands. Since this condition does exist, I feel justified in encouraging a training program for county extension workers who are in direct contact with farm people. Since rural electrification is a phase of the agricultural program, county extension workers will contribute their part to a rural electrification program provided they have sufficient knowledge at hand relating to the subject.

There are certain fundamentals of vital importance to any organization planning a rural electrification program, namely, (1) a program relating to good farm and home management practices, (2) a program planned for a definite type of farming area, (3) a program that will get action from the people for whom it is intended, (4) a program to use effectively and efficiently the various existing federal and state agencies interested in rural electrification, and (5) a program in which results and progress can be measured.

There are a number of ways that we can materially aid our rural electrification extension programs, of which we no doubt have thought, but to my knowledge very little has been done to encourage these aids. Some of them are as follows:

1 An exchange of ideas among states having common objectives. Four of the southern states for the past two years have been holding semiannual conferences, which last two days, to discuss common problems and activities relating to extension projects in rural electrification. We have observed that such conferences are most helpful and do not hesitate in suggesting that they be given a trial in other sections of the country.

2 An opportunity to study procedures that have been used in conducting successful projects in other states. Such essential information could be made available to all extension organizations, possibly through the U. S. D. A. agricultural extension engineer, C. R. E. A. news letters, or even through AGRICULTURAL ENGINEERING.

3 Preparation of bulletins that could be exchanged among states having common problems and similar type of agriculture. This has been done in the farm building work and was headed by the Bureau of Agricultural Engineering in Washington. At our last rural electrification conference, the Georgia extension service agreed to publish a bulletin on fractional horsepower motor applications, the Mississippi extension service one on electric hotbeds, and the Tennessee extension service one on lights for the farm yard and buildings. The type of bulletin desired by each of the extension services represented was discussed in full detail, and surprisingly as it may seem we found that each extension service desired about the same type of information to be included in the bulletins. This meant that we would have more time in preparing one good bulletin and at the same time be assured that three good bulletins were being prepared and could be published by each extension service for general distribution.

4 If rural electrification is to keep pace with other phases of agriculture, the agricultural engineering and home economics departments in state colleges should offer more basic education in rural electrification, especially for those students who are fitting themselves to become county extension workers, vocational teachers, and farmers. Extension specialists in rural electrification can be of great assistance to resident instructors in formulating practical courses, as they are familiar with the existing conditions in the field.

TRAINING SCHOOLS

The extension director in Tennessee is fully aware of the fact that his field force carrying on agricultural work with farm people are in need of training in rural electrification, and has approved a training school for them. After carefully studying the problem he deemed it advisable to hold a series of short schools rather than one long school covering the entire field of rural electrification. He felt it best that the county extension workers cover one subject well, and have an opportunity to put it into practice before taking up another.

Our schools are set up to first cover the subject of farm wiring and lighting, as this is considered fundamentally the first stage in rural electrification development. Similar schools on specific farm and home electrical equipment will follow the farm wiring and lighting schools at about six-month intervals. It is neither the intent or desire to develop trained electricians, but rather to develop a basic knowledge of what constitutes a satisfactory and complete wiring and lighting installation. Most farm people have insufficient electric knowledge at hand to plan their layout as they should. Through trained extension workers, vocational agriculture and home economics teachers, rural service representatives, and others, it is hoped that farm people will have ready access to practical advice. A definite attempt is made to adapt the course to southern farm conditions.

Training School Procedure. The schools are designed to cover the subject matter and laboratory work in three days. Laboratory work is taken up after discussion of each of the following subjects: Electrical terms and definitions; wire types, capacities, and voltage drop; workmanship; inside wiring; outside wiring; and wiring layout for the farmstead.

There are four extension districts in Tennessee, each having a district man and woman agent, who organize the schools in their districts. We have found that a group of twelve to sixteen is sufficient in number to attend one

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Presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 1, 1938. Mr. Johns (Mem. A.S.A.E.) is extension agricultural engineer in rural electrification, University of Tennessee.

school, as it is difficult for one instructor to handle more than this number in laboratory work. Schools for men and women agents are held jointly. These schools are held first in those counties where rural electrification development is most active. Arrangements are made to hold the schools in vocational agricultural high school buildings that are centrally located in respect to adjoining counties so that each person attending can drive from home each morning.

GROUP MEETINGS WITH FARM MEN AND WOMEN

These meetings are called by county extension workers in communities about ready to receive electric service for the first time. Whenever possible small group meetings are actually held on farms. They are from two to three hours in length, depending entirely on the interest of the farm people attending. At these meetings, the discussions start with the service entrance, explaining the advantages of 115-230-volt service, types of distribution panels, branch circuits, and special circuits. Each room in the house is taken up separately as to the best location of convenience outlets, fixture outlets, switches, and selection of proper lighting fixtures. It is our aim to point out to the farm people what constitutes a good wiring layout and to plan their wiring for future needs instead of for the present. This also enables the farmer and wiring contractor to have a better understanding as to what is desired in the way of wiring. We also discuss in brief at these meetings points to bear in mind in selecting various household and farm electrical equipment, stressing that each farm family should have a planned program as to how they can use electricity to the best advantage, although it may take a number of years to complete their plan.

RURAL ELECTRIFICATION DEMONSTRATIONS

Our extension rural electrification demonstrations are divided into three distinct projects: (1) electro-development demonstration farms, (2) income producing equipment adapted to defined farming areas, and (3) farm and home electrical equipment demonstrations.

Electro-development Farm Project. This project is set up primarily to aid farm people in making a better and more profitable use of electricity in the home and on the farm, and also to focus attention in the community on the practical uses for electricity. The farms are selected on the basis of compliance with certain requirements. The main consideration in making selections will be adequate and intelligent use of electricity consistent with the type of farm. Electric equipment is supplied by the farmer and not by the sponsoring agencies. Approved farms or those interested in qualifying will form the nucleus for an educational and demonstrational electrification program in the county. The general requirements for any farm to become an electro-development farm are that (1) the farm should be reasonably accessible, typical of the region and well managed, and it is not necessary that is be a show place, but it should be neat and orderly and carrying out the good farm and home management practices recommended by the extension service; (2) the farmer and his wife should be good cooperators; (3) the farm should not only demonstrate the mechanics of electrical installations but also the economical and social results of their use, and (4) the future development of the farm and home should be considered as well as the immediate appearance of the premises and variety of uses for electricity. In addition to the above, such requirements as those relating to proper and adequate wiring and lighting, household, and farm equipment are definitely set up in the project.

This project is sponsored by the state extension service cooperating with the local power distribution agencies, Tennessee Valley Authority, and other agencies interested in this particular type of demonstration. The farms are judged by a county rural electrification committee selected by the county extension workers. The state rural electrification specialist is also a member of this committee.

The anticipated results of such a project are more effective and profitable uses of electricity on farms, more intelligent and economical spending for wiring and electrical equipment, increased use of electric service, and better farm and home management, resulting in higher living standards. The project has been in operation less than a year, and we have four qualified electrodevelopment farms in the two counties which we have worked and sixteen applications on file.

It is our aim in this project to establish actual demonstrations on farms of income-producing equipment that has a wide application in a definite type of farming area. An example of this type of demonstration may be found in two counties in the western part of our state, where truck cropping is the main source of income. Prior to 1936 there was not one electric hotbed in operation in this area, but due directly to the results of a few electric hotbed demonstrations in 1936, there are now ten large electric hotbed installations in this small area that are proving their economic value. After such income-producing equipment has been in operation for a period of time, the county extension agents sponsor meetings of farmers interested in this particular project. The cooperating farmer gives facts on cost of installation, cost of operation, labor saved, and higher quality of products produced.

This type of demonstration has been used mainly to familiarize farm people with the various economical and practical uses of electricity. Demonstrations of this type are generally held in conjunction with farm institutes, state and county fairs, and electrical expositions. Demonstrations of this nature have been sponsored by the extension service cooperating with dealers, manufacturers, power companies, and power associations. Five such demonstrations were held in Tennessee the past year attended by eight thousand farm people. Our extension service is gradually getting away from this type of demonstration, not because we have not realized favorable results, but because we feel that such agencies as power companies, power associations, and dealers should sponsor exhibits or demonstrations of this type.

Too much emphasis cannot be placed on the importance of setting up a definite 4-H rural electrification project in the state. To do an affective job, this project should be carried on by both the rural electrification specialist and county extension workers. I believe that, through training schools as previously discussed in this paper, county extension workers will be better fitted and will be more likely to include rural electrification in their county 4-H club programs.

The activity in rural electrification of our extension service during the past two years with 4-H club members has been largely confined to demonstrations of farm and home electrical equipment at district 4-H club camps, and in giving assistance in the 4-H club rural electrification contest sponsored by one of the electrical manufacturing companies. From this contact, we have found that club members are exceedingly interested and ready to take up definite projects.

Any rural electrification program, to be effective, must be made an integral part of the agricultural program of the state. This fact should always be kept in mind when developing a rural electrification program. Only in this way will the farm family receive the maximum benefits from the extension service in making full and intelligent use of electricity.

Low-Cost Cooling for Residences

By C. K. Otis

MODERN air conditioning, which makes use of mechanical refrigeration, can be designed for practically any need. The initial cost of installation and the operating cost are so high that this modern comfort seems definitely beyond the reach of the majority of people. Most people must look toward simpler and cheaper methods of cooling their homes.

A simple method which has been in common use for years is called cooling by night air. This practice consists of opening the house during the night and allowing the cooler night air to circulate through the rooms and take out the heat accumulated during the day. In the early morning the windows are closed, the shades drawn on the sunny side, and the cool interior preserved throughout the day. Some additional comfort may be obtained by means of a fan which circulates the cooler basement air through the house. The success of night air cooling depends upon a well-insulated house of good size. It also loses its effectiveness during long-continued hot spells when the walls and floors gradually get hotter.

In the drier sections of the country, night temperatures are surprisingly low, even when heat records are broken during the day. People who retire in hot rooms and do not arise before the sun has been shining for two or three hours do not realize that these cool night temperatures prevail. The data taken from Manhattan, Kansas, during July and August of two recent very hot summers show a mean minimum temperature of 70 F (degrees Fahrenheit) during a period when the maximum daily temperature was 105 to 110 F (Fig. 1). During these very hot months this night air was available to cool the homes and to provide reasonably comfortable inside conditions.

Night air may be circulated through the home in a number of different ways. The simplest of these is to provide natural attic ventilation by means of open windows or suitable louvers for free passage of air. A centrally located opening should be provided in the attic floor for the escape of the hot air from below. All windows on first and second floors should be opened in the evening. As the hot air in the rooms rises to the attic and escapes, the cool air is drawn in through the open windows.

Another method may be used in connection with a warm air heating system by installing a large fan in the basement to force outside air to all the rooms through the heating pipes, and using the attic ventilator for the escape of the hot air.

The third method, and the most effective one, is to install a large fan at the opening in the attic floor, discharging into the attic space and thence to the outside through openings in the end wall or dormers. This fan in the attic attacks the hot air at the place where most of it accumulates and creates ventilation which is immediately effective. All windows may be opened to cool the entire house, or a greater air movement can be created through windows into a single room for more rapid results.

Fig. 2 shows temperature-time curves plotted from data obtained in a two-story frame house equipped with this type of system. Four curves, representing average temperatures in the attic, the upstairs, the downstairs and the outside air, are carried through one complete 24-hr cycle. The fan was turned on at 6 p.m. and all windows were opened at the same time. At 6 a.m. the next morning the fan was stopped, all windows were closed, and the shades were drawn on the sunny side of the house. It is seen by the curves that after midnight all temperatures go down at about the same rate. When the sun comes up in the morning, the outside temperature begins to rise. The fan is stopped soon after the outside temperature starts up, so that the house starts the day as cool as possible. As soon as the fan stops, all temperatures climb, but at different rates. When the outside air reached its peak, at about 2 p.m., the upstairs and downstairs temperatures were still moderately cool.

Modern fans designed for this kind of service are available on the market. They run at slow speeds, 300 to 400 rpm, are quite noiseless, and yet deliver large volumes of air. Changing the air in the house fifteen to twenty times per hour will give effective cooling.

Cooling the air in the home by the use of well water is the second example of low-cost cooling. Wherever the temperature of the ground water is 60 F or lower, and a plentiful supply is available near the surface, this system can be made to work. In general, the complete system consists of a well, a water pump, a radiator, a fan or blower, and means of distributing the cool air to the rooms (Fig. 3). As the water is circulated through the radiator by means of the pump, the air is blown across the surface, thus giving up some heat to the water. The cooled air picks up heat from the rooms and returns to the fan where it is again passed through the radiator. On the average, about one

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 30, 1938, and subsequently revised for publication in AGRICULTURAL ENGINEERING as Contribution No. 88, of the agricultural engineering department, Kansas State College. Mr. Otis (Mem. A.S.A.E.) is instructor in agricultural engineering at Kansas State College.

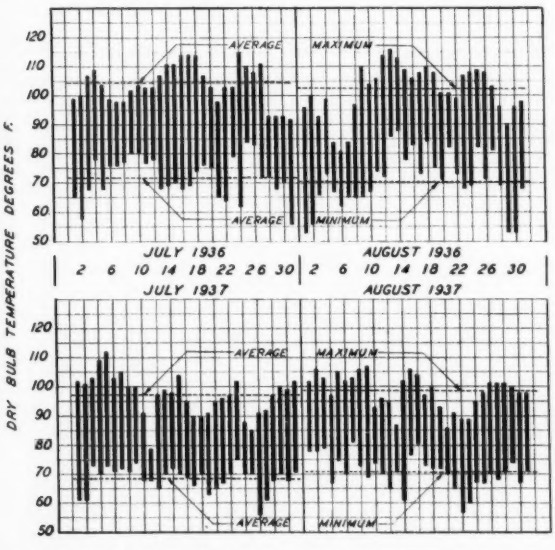

FIG. 1 MAXIMUM AND MINIMUM DAILY TEMPERATURES AT MANHATTAN, KANS., DURING JULY AND AUGUST, 1936 AND 37

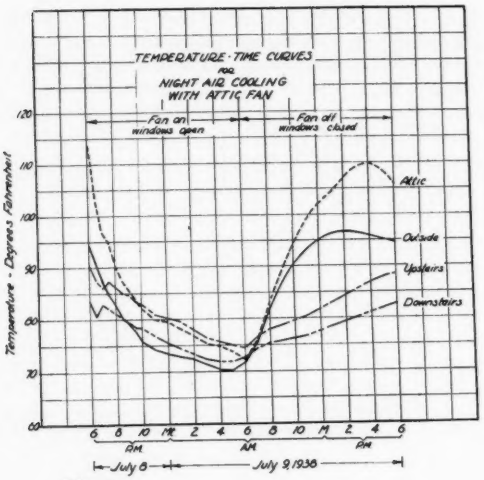

Fig. 2

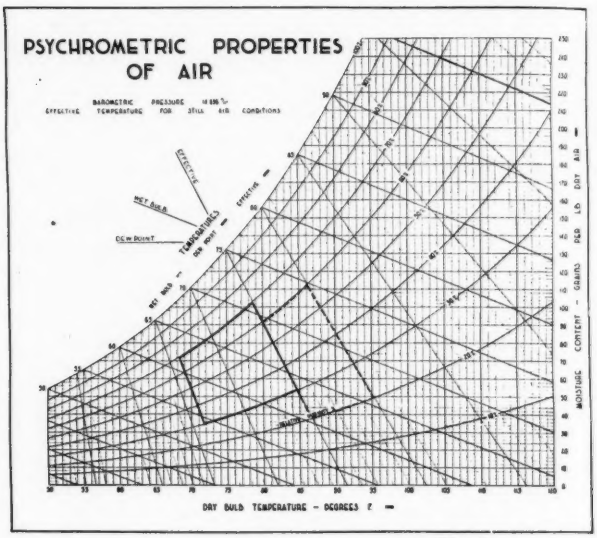

Fig. 4

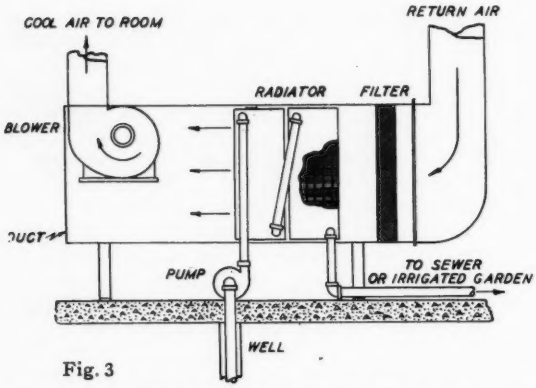

Fig. 3

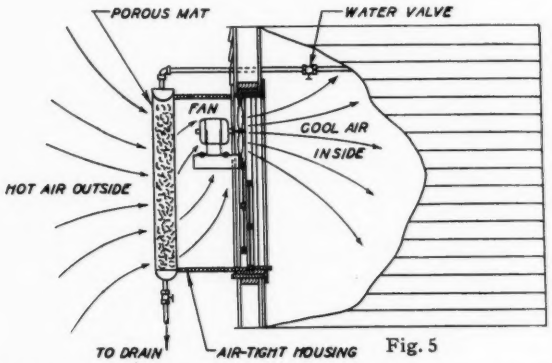

Fig. 5

FIG. 2 CURVES SHOWING A 24-HOUR CYCLE OF TEMPERATURES IN A RESIDENCE COOLED WITH NIGHT AIR. FIG. 3 ESSENTIAL EQUIPMENT FOR COOLING HOMES WITH WELL WATER. FIG. 4 PSYCHROMETRIC CHART SHOWING THE ACCEPTED SUMMER COMFORT ZONE FOR STILL AIR, AND A POSSIBLE EXTENSION OF THE ZONE FOR VERY HOT WEATHER. FIG. 5 DIAGRAM OF A WINDOW BOX COOLER USING THE EVAPORATION METHOD OF COOLING AIR

gallon of water per minute must be circulated through the radiator for each 1300 cu ft of space cooled when the water temperature is 60 F. Ordinary sized homes use 4 to 5 gal of water per minute. The water is available for irrigating lawns and garden, or may be pumped to tanks for the livestock.

A large number of these cooling systems have been installed in Kansas in recent years, many of them being of the temporary, makeshift variety. A small, motor-driven rotary pump may circulate water through an old car radiator set in the corner of the room and connected by garden hose to the pump in the basement. An ordinary electric fan set back of this radiator drives air through the radiator and circulates the cool air through the room. A system of this kind may give results which are quite satisfactory. Other systems installed by the plumbing and heating contractors use standard equipment designed for this purpose and are permanent installations. Data on six of these water-cooled systems are given in Table 1.

TABLE 1. DATA ON WELL WATER COOLING SYSTEMS INSTALLED IN MANHATTAN

Unit No.	Well Depth, ft.	Well Cost	Motor Pump, hp	Motor Fan, hp	Cost of System Installed	Cost of System Per hour of operation	No. of rooms cooled
1	60	$15.00	1/5	1/12	$86.00	$0.01	5
2	34	8.00	1/4		50.00	.013	2
3	50	150.00	3/4	1/2	550.00	.05	8
4	64	42.00	1/3	1/6	126.00	.02	6
5	52	37.00	1½	1/2	425.00	.05	8
6	58	75.00	1/2	1/3	500.00	.01	8

In examining these data, 53 ft seems to be the average depth of well, the total cost of the systems ranges from $58 to $700, and the number of rooms cooled is from two to eight. Motors for pumping range from 1/5 to 1½ hp, and fan motors used are 1/12 to ½ hp.

This method of cooling air is limited to locations where water temperatures are 60 F or below, and where it is close enough to the surface for economical pumping. This method is well adapted to use for farm homes because the water pumped can be used for other purposes.

The possibilities and limitations of this type of cooling can best be shown by means of psychrometric properties of air and water vapor mixtures (Fig. 4). This chart shows dry-bulb temperatures plotted horizontally and moisture content of the air vertically. Relative humidity lines are

TABLE 2. SUMMARY OF DATA OBTAINED FROM WELL WATER SYSTEM COOLING A HOTEL DINING ROOM

Outdoor air temperature	96 F
Outdoor air relative humidity	36 per cent
Room air temperature	78 F
Room air relative humidity	58 per cent
Temperature of water entering radiator	61 F
Temperature of water leaving radiator	66.5 F
Gallons of water per minute to radiator	13.6
Cubic feet of air supplied to room per minute	3028

curved diagonally across the chart. Outlined in heavy full lines is shown what is known as the comfort zone for still or nearly still air. Crossing the relative humidity lines at nearly right angles are lines of equal comfort known as effective temperature lines. For example, it has been found that 98 per cent of a group of people would be comfortable anywhere on the 71-deg effective temperature line. If it were 82 F, dry bulb, and 10 per cent relative humidity, by definition of effective temperature, you would have the same feeling of warmth as you would if the air were 75 F at 60 per cent relative humidity. It has been found that above a 75 F effective temperature, less than one-third of the group would be comfortable, and, likewise, less than one-third would be comfortable below 66 F effective temperature. Consequently the upper and lower limits of effective temperature provide the ends for our comfort zone. Since investigations have been carried on only between 70 and 30 per cent relative humidity and since very high and very low relative humidities seem to provide somewhat disagreeable sensations, the top and bottom of the zone are fixed at these points. Within this zone of summer comfort at least 30 per cent of any group of people in a climate similar to ours will feel comfortable at any air condition falling within this zone. For any air-conditioning system the conditioned air must be such as to fall within the borders of this box in still air to meet average comfort requirements.

The horizontal lines are lines of equal moisture content which show the condition that prevails in well water cooling. Unless the air can be lowered in temperature to the dewpoint, no moisture can be taken away from it by cooling and since the cooling water is enclosed within the radiator, no moisture is added to the air. If we have air at 100 F and 30 per cent relative humidity, which is a common summer air for Manhattan, cooling with well water to 74 F, dry bulb, would result in air at 68 per cent relative humidity, which falls within the comfort zone on a 71 F effective temperature line. This is satisfactory for comfort. Starting at 100 F and 40 per cent relative humidity we would be unable to obtain comfort conditions unless we cool to saturation, condense out some of the moisture, and allow the air to warm up again, which can be done with 60 F water in many cases. Ten per cent relative humidity in air at 100 F could not be conditioned with well water without adding moisture to the air, providing our arbitrary 30 per cent line on the bottom of the comfort zone is correct. Since Kansas summer air of 100 F, dry bulb, frequently has a relative humidity of between 20 and 30 per cent, it can be seen from this chart that, with well water temperatures of 60 F, cooling by this method is practical for our climatic conditions.

There is the possibility of removing moisture from air as it leaves the cooler by means of silica gel, or some other mineral having great affinity for water. It is possible that this might increase the flexibility of the well water cooler, making it possible to condition air of higher relative humidity. For instance, again consulting our comfort chart, if air is taken at 100 F, and 35 per cent relative humidity and cooled to 70 F by the radiator, we could not produce comfort conditions, but if upon reaching 70 F we could remove moisture at constant wet-bulb temperature, which is the case when using silica gel, we could raise the dry-bulb temperature to 78 F and fall within the comfort zone.

A third method of low-cost cooling for homes is air cooling by evaporation. This is an interesting phenomena misunderstood by many. To change a liquid to a vapor requires a considerable amount of heat, although its temperature is not changed in the process. When evaporating water by passing a current of air over its surface, the heat necessary to change the liquid to a vapor is supplied by the air. The temperature of the air is reduced, but the total heat of the air and vapor mixture remains the same. The heat taken from the air in reducing its temperature has been replaced by the latent heat of the moisture added to it. The wet-bulb temperature remains the same and the relative humidity increases. This can be seen on the chart, represented by the flatter diagonal lines. Starting at 100 F and 30 per cent relative humidity, cooling by evaporation (constant wet-bulb temperature), the maximum possible gives a dry-bulb temperature of approximately 74 F and 100 per cent relative humidity. This is far above the comfort zone for still air. Starting with 20 per cent relative humidity, it is found that comfortable conditions can be obtained by this method when cooling the air to a dry-bulb of about 78 F which will give a relative humidity of 65 per cent. Ten per cent relative humidity with a temperature of 100 F would give opportunity to cool the air by evaporation to a point well within the comfort zone.

It appears from this chart that cooling air by evaporation must be confined to outside air of low relative humidity.

Recirculation of air in evaporative cooling is out of the question because of the building up of moisture content.

If evaporative cooling is to be considered practicable, we must admit that the zone of comfort extends farther into higher temperatures than the one shown. This extension is

TABLE 3. REPRESENTATIVE RESULTS OF EVAPORATIVE COOLING TESTS

Test No.	Outside Air: Dry bulb, F	Outside Air: Wet bulb, F	Outside Air: Relative humidity per cent	Outside Air: Effective temperature, F	Air Leaving Cooling Unit: Dry bulb, F	Air Leaving Cooling Unit: Wet bulb, F	Air Leaving Cooling Unit: Relative humidity, per cent	Air Leaving Cooling Unit: Effective temperature, F	Amount of water used: gph	Amount of water used: gph per 1000 cu ft
1	93.2	70.6	33	80.8	81.2	71.6	64	76.5	3.4	.032
2	87.9	69.2	39	78.2	69.7	68.6	94	69.2	3.3	.039
3	93.0	73.3	40	81.8	78.2	73.5	80	75.8	2.5	.030
4	93.0	71.2	35	81.0	78.0	71.4	74	74.8	2.3	.029
5	90.0	75.0	51	81.4	75.8	74.9	96	75.3	3 5	.027
6	100.5	66.8	16	81.8	77.0	66.3	58	72.4	5.7	.043
7	101.0	74.5	29	84.7	77.4	74.8	89	76.2	2.9	.038
8	101.8	76.0	31	85.5	82.8	75.6	73	78.9	3.9	.033
9	101.9	78.4	36	86.6	84.3	78.0	76	80.7	3.8	.028
10	100.3	73.7	29	84.2	82.1	73.4	67	77.7	4.4	.029

indicated on the chart in heavy dotted lines extending to the 80 F effective temperature line and relative humidities between 20 and 60 per cent. Within this zone, hot air 100 to 105 F can be cooled effectively when the relative humidities are 25 per cent or lower.

Thousands of these evaporative coolers have been in use in the Southwest during the past few years. Most of them are simple, makeshift devices which have been rigged up as emergency coolers in order to secure some relief from the heat. The window box cooler which is most common (Fig. 5) has some porous material like excelsior, cotton fabric, or coke, which is kept wet by a water spray. Air is blown or drawn through this wet material where evaporation of the water cools the air. Small units are on the market which can be set in a room. These units do not promise to be of much value because the recirculation of the air will build up the humidity to a point well beyond the comfort zone.

Table 3 shows some data obtained from tests using the evaporative method of cooling air. These tests were made with an experimental apparatus constructed by the department of agricultural engineering of Kansas State College for the purpose of studying various means of cooling air by evaporation.

While these tests were being run, the atmospheric conditions were, for the most part, unfavorable to evaporative cooling. It can be seen by the psychrometric chart (Fig. 5) that to cool air by evaporation to a point within the extended comfort zone would necessitate a wet-bulb temperature of the incoming air below 75 F. To fall within the accepted summer comfort zone, the wet-bulb temperature must be 71 F or below. Thus tests numbered 1 and 4 show that the outside air could be conditioned to a point just above the accepted comfort zone. Tests 2 and 6 show conditions under which evaporative cooling would be successful in obtaining summer comfort by accepted standards. The fact that air leaving the cooling unit is at a condition above the comfort zone does not necessarily mean that the rooms into which it is discharged will not be maintained within the zone, because in mixing with the warm, dry air of the room it may form a mixture that will fall within the zone. The velocity of the air through the cooler determines to some extent the condition of the air leaving the cooler. Increasing the velocity does not allow sufficient time in the cooler for the air to approach saturated conditions. In test No. 2 the air velocity through the cooler could have been increased so that the conditioned air would leave the unit at 78 F, with a relative humidity of 64 per cent, which is within the comfort zone.

Tests 3, 7, and 10 show air conditions that could probably be cooled by evaporation to a point within the extended comfort zone and would no doubt be welcome relief from the outside heat, especially if accompanied by plenty of air movement. In all cases it is shown that the effective temperatures have been materially reduced. The amount of water used is very low as compared to that needed for well water systems, and bringing the air into contact with the water has a cleansing effect on the air, removing pollen and dust.

Circulating air with a low-dry-bulb temperature through the house will help to reduce the wall temperature, as well as objects in the rooms, even though its relative humidity is high. Although the air itself does not meet the requirements of comfort, it should be helpful in reducing the amount of heat radiating from the walls. Since air cooling by evaporation depends on low wet-bulb temperatures for success, its use will be limited to areas where low wet-bulb temperatures prevail.

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NEWS

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

PRESIDENT PROPOSES $3,060,000,000 LOAN PROGRAM

AS A means of further stimulating employment in the construction and heavy industries without additional increases in the national debt, President Roosevelt on June 22 suggested, in a letter to Senator James F. Byrnes of South Carolina, that the federal government embark upon a program of loaning, at low interest rates, funds for self-liquidating public and semi-public improvements and betterments. This money would be procured by the sale of obligations of government corporations and other agencies, to be repaid as to principal and interest through the earnings of the projects constructed. The liability of the federal government would be limited to a guarantee to meet possible defaults and would thus be a contingent, rather than a direct, obligation.

Proposed as a supplement to the work-relief program and as a substitute for any further extension of the PWA loan-and-grant method of stimulating construction, the President's plan suggests a number of possible channels for these self-liquidating expenditures:

1 Non-federal public works, such as waterworks, sewage disposal plants, hospitals, bridges and other facilities from which income would be received (either in the form of direct revenues or through taxation for services rendered) could be stimulated, the President believes, by offering loans at low interest rates to the extent, it is estimated, of $150,000,000 in the fiscal year now beginning, and a total of $350,000,000 for a two-year program. This is the direct substitute for the present PWA program.

2 Highways and bridges, particularly toll roads, bridges, high-speed highways and by-pass roads; a four-year program estimated at $750,000,000 of which $150,000,000 would be used during the current fiscal year.

3 Railroad equipment, to be purchased by a federal agency and rented or sold to the railroads: $500,000,000 in three years; $100,000,000 during the first year.

4 Rural electric lines. through an increase in the present program of the Rural Electrification Administration, could account for an additional $20,000,000 during this fiscal year, and a total of $460,000,000 over a seven-year program.

5 Loans in rural areas for tenant farm purchases, rehabilitation, improvements and repairs to buildings, resettlement cooperatives, and for irrigation and drainage facilities would account for $250,000,000 per year for the next two years.

6 Foreign loans to the extent of $200,000,000 the first year, and a total of $500,000,000 in two years, would stimulate the purchasing of American goods for export.

Not formally listed in the President's program, but mentioned as fitting into the general scheme, is the proposed increase of $800,000,000 in the amount that could be loaned local housing authorities for slum-clearance projects by the U. S. Housing Authority. This would increase his estimated total for all loans over the various periods listed to $3,860,000,000.

TRADE COTTON FOR RUBBER

Supplementing the acquisition by this country of strategic minerals by outright purchase approved by Congress last month, (see June Bulletin on page 3) the United States and Great Britain have agreed on an exchange of 600,000 bales of cotton for approximately 175,000,000 pounds of rubber, the exact amount depending upon price averages for the past six months. Both countries will hold the acquired materials off the commercial market for a period of seven years for use only in case of a major war emergency.

Negotiations are also under way with other countries which will result, it is hoped, in the exchange of surplus American cotton and wheat for tin and other critical war materials imported into this country.

UTILITY STUDY ISSUED

A statistical study of the operations of 385 privately- *(Continued on page 284)*

A.S.A.E. "FAMILY" PARTY

The group of men, women, and children below constitutes a large portion of those attending the 32nd annual meeting of the American Society of Agricultural Engineers held on the campus of the school of agriculture, University of Minnesota, at St. Paul, June 19 to 22, 1939. That it was very much of a "family" gathering is quite evident from the picture. And it may be said a "good time was had by all"

North Atlantic Section Program Planned

SEPTEMBER 12, 13, and 14 are the dates set for the yearly meeting of the North Atlantic Section of A.S.A.E. September 15 has been set aside for a day at the New York World's Fair. The meeting is to be held at the New York State Institute of Applied Agriculture, at Farmingdale, Long Island, about a 45-minute drive from the fairground.

Arrangements have been made for opening two dormitories and the dining hall at the Institute to accommodate those attending the meeting. These will take care of the first 120 persons who signify their intention of attending. The rate will be $3.00 per person per day, including lodging, meals, and the banquet on the night of September 14. Joseph S. Webb, chairman of the North Atlantic Section, has indicated his belief that these are the best accommodations and rates available within a reasonable distance of the Fair. Other accommodations will be available nearby to take care of the balance of the meeting group.

Program features of the opening session will include an address by H. B. Knapp, director of the New York State Institute of Applied Agriculture; a message from the Section chairman, J. S. Webb; "'Ultra' in Lamps and Lighting," and "First Aid to the Ailing Farm Home."

An evening round table the same day will cover the four technical subdivisions of agricultural engineering. L. F. Livingston and C. A. Frye are tentatively scheduled to lead the discussion on soil conservation; M. G. Huber, power and machinery; W. C. Krueger, structures; and George Kable, rural electrification.

Subjects for the second day include "Quick Freezing on the Farm," "Grass Farming and One-Story Barns," "Field Irrigation and Water Supply," "Parks and Parkways and Their Importance as Transportation Lanes for Agricultural Products," and the "U.S.D.A. Rural Electric Research Survey."

Topics scheduled for the third day are "Soil Erosion," "Air Conditioning and Ventilation for Barns and Farm Buildings," "Lessons Learned from the New England Hurricane," "Farming on Land Valued at $4,000 an Acre and Making a Profit," "A Program of Applying Engineering to Farming," and "Farm Implement Research," illustrated.

K. J. T. Ekblaw, president of the American Society of Agricultural Engineers, is scheduled to make the banquet address.

The World's Fair day offers as feature attractions the electrified farm and a special trip through the du Pont Building.

Wives of the committee have arranged a special program for the entertainment of ladies attending.

Henry Espensen, (center) receives on behalf of the Iowa State College Student Branch of A.S.A.E. the 1939 Farm Equipment Institute Cup. The award is made each year by the American Society of Agricultural Engineers. Frank. J. Zink (right) chairman of the Committee on the F.E.I. Award, presented the cup, while Dr. J. B. Davidson (left) looked on

ASAE Meetings Calendar

July 25, 1939—Pacific Coast Section, Treasure Island, San Francisco, Calif.

September 12-14, 1939—North Atlantic Section, Farmingdale, Long Island, New York.

Washington News Letter

(Continued from page 283)

owned electric utility companies, comprising about nine-tenths of the industry, for the calendar year 1937 has been published in two volumes by the Federal Power Commission and is available at $2 per set.

Covering companies with annual revenues of $250,000 or more, the report reveals total electric revenues of $2,157,277,266 from the operation of total assets valued at $16,873,384,102. Outstanding securities total $13,378,579,835, of which bonds and other long-term obligations account for $6,850,194,447; preferred stocks $2,125,431,564; common stocks $4,306,363,835.

Residential customers during the year averaged 19, 627, 633 in number, and paid $645,748,799 for 14,821,890,000 kilowatt-hours of power, an average of 755 kilowatt-hours per year per customer at an average cost of 4.3 cents. Commercial and industrial sales accounted for 65,202,088,000 kilowatt-hours of consumption, $1,105,092,543 of revenue, an average price of 1.7 cents.

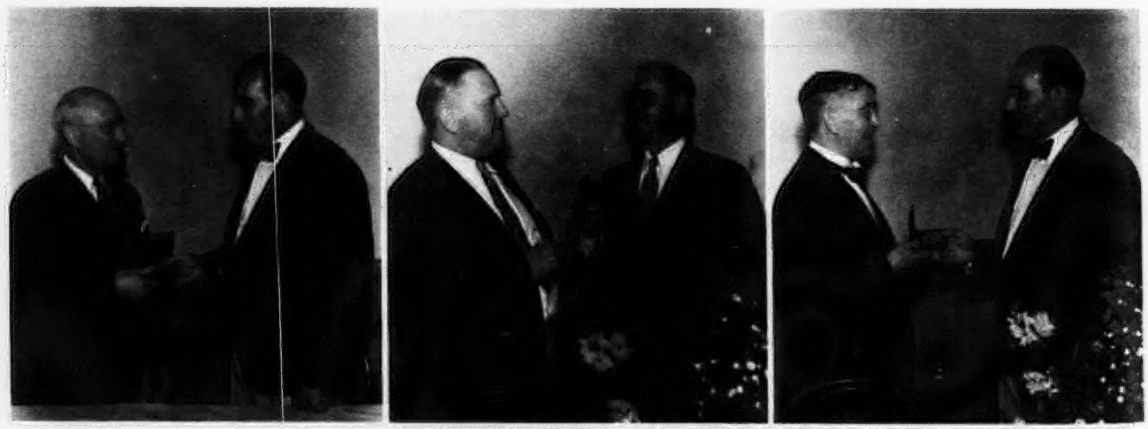
Necrology

WALLACE FORREST MACGREGOR, director and chief engineer of the J. I. Case Company, passed away June 19, at the age of 65, after an illness of three months. He joined the Case organization shortly after receiving his master's degree in mechanical engineering in 1898 at the University of Wisconsin. He had been a member of the A.S.A.E. since 1909, and served as president of the Society in 1914.

Starting his career when the steam engine was being introduced as a source of farm power, he was prominent in its development, and for his contributions to the design of modern threshers, combines, hay balers, silo fillers, and other farm machines.

Mr. MacGregor was also active in the American Society of Mechanical Engineers, especially in the steam boiler code work. He was a member of the Presbyterian Church, of the Racine school board for eight years, and of several other business, civic, and social organizations. He is survived by his widow, the former Miss Jessie Louise Hand, a daughter, two grandchildren, and four sisters.

(News continued on page 286)



(Left) Harry Bruce Walker (left), receiving from L. J. Fletcher (right), chairman of the Jury of Awards, the 1939 award of the John Deere Gold Medal awarded by the American Society of Agricultural Engineers at its 32nd annual meeting held last month at St. Paul, Minn. (Center) K. J. T. Ekblaw (left) is inducted into the office of President of the A.S.A.E. by the outgoing president, S. P. Lyle (right) during the annual dinner of the Society, June 21. (Right) Philip Sheridan Rose (left) receiving from Mr. Fletcher the 1939 award of the Cyrus Hall McCormick Gold Medal at the Society's annual dinner

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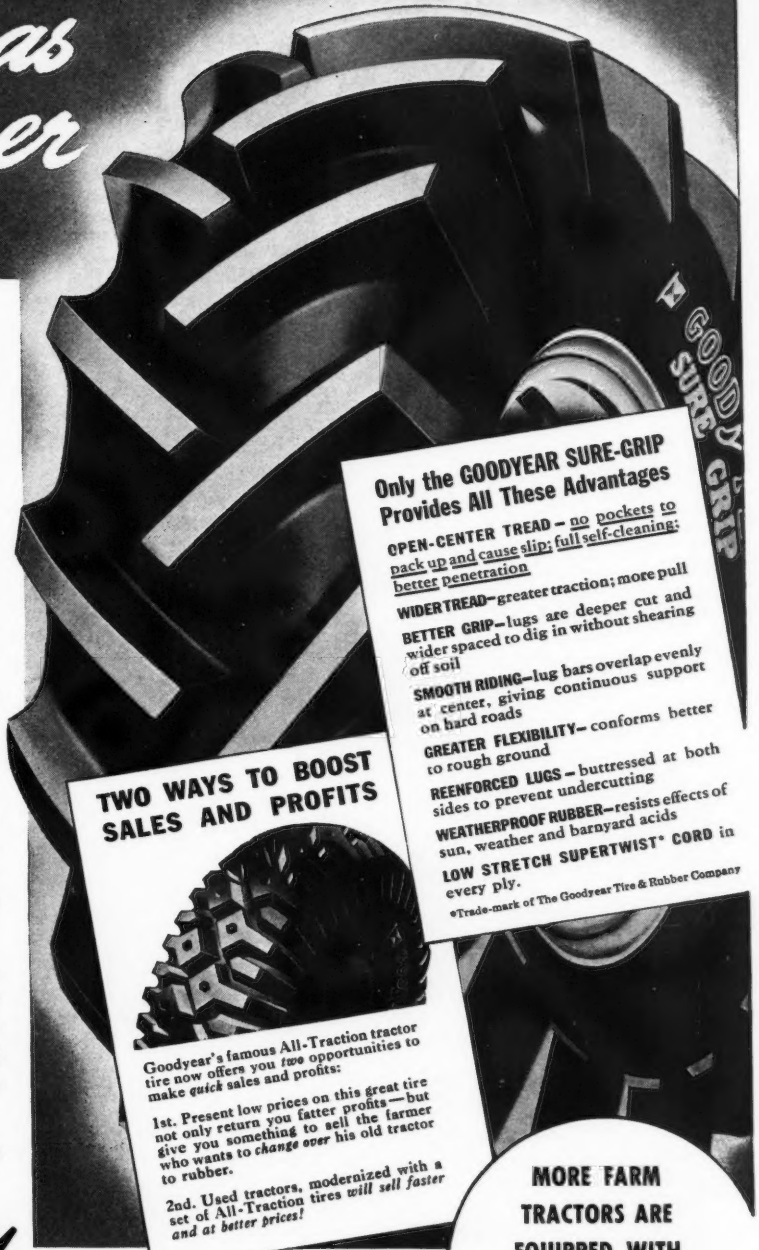

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TRACTOR AND IMPLEMENT TIRES

National Council of Student Branches Elects Officers

DURING a business session of student branch representatives at the A.S.A.E. annual meeting in St. Paul, in June, the annual election of officers of the National Council of Student Branches was held, the following being elected: Raymond C. Fischer, president (University of Wisconsin); Norman Akesson, first vice-president (North Dakota State College); Henry Espensen, second vice-president (Iowa State College); and Edward Miller, secretary (Ohio State University).

Personals

W. Eugene White has resigned as assistant agricultural engineer for Nebraska to become irrigation and lighting engineer for the Western Public Service Company of Scottsbluff, Nebraska.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the June issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

M. S. Adams, 177 First St., Athens, Ga.

Vincent J. Barlow, agricultural engineering aide, Soil Conservation Service. U. S. Department of Agriculture. (Mail) 216 Security Mutual Bldg., Lincoln, Neb.

R. C. Barnes, Jr., RFD No. 3, Belton, Tex.

W. V. Bass, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Perry, Ga.

James E. Beamish, agricultural engineer, Dominion Experimental Station. (Mail) Maple Creek, Sask., Canada.

Milton V. Beckham, Edison, Ga.

Carl Behn, vice president, American Bosch Corp., 3664 Main St., Springfield, Mass.

Hatto M. Berg, Fredericksburg, Tex.

W. D. Bland, Jr., district supervisor, Agricultural Adjustment Administration. (Mail) Millington, Tenn.

H. D. Bruhn, research engineer, department of agricultural engineering, University of Wisconsin, Madison, Wis. (Mail) RFD No. 2, Mendota Beach.

F. L. Burrell, 724 S. Lumpkin St., Athens, Ga.

Harold J. Butler, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Booneville, Ark.

Charlie H. Case, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 910, Colorado City, Tex.

G. W. Clark, Jr., 19 Grady St., Statesboro, Ga.

Hugh Clark, Flowery Branch, Ga.

Edward O. Cone, 724 S. Lumpkin St., Athens, Ga.

W. J. Coultas, chief experimental engineer, John Deere Harvester Works, Moline, Ill. (Mail) 4510 5th Ave.

Fred M. Crawford, research fellow, Iowa Agricultural Experiment Station, Ames, Iowa. (Mail) Agricultural Engineering Department, Iowa State College.

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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

THE COMBINED EFFECT OF LIGHT AND GRAVITY ON THE RESPONSE OF PLANTS TO GROWTH SUBSTANCES, *P. W. Zimmerman* and *A. E. Hitchcock*. Contrib. Boyce Thompson Inst., 9 (1938), No. 5, pp. 455-461, figs. 2. Stems (mainly tomato) treated unilaterally with lanolin preparations of growth substances made pronounced bendings in the dark or under light from all directions. This was also true of stems treated immediately on placing the plants horizontally or in unilateral light. When plants were allowed to make natural tropic responses before application of the synthetic substances, the induced responses were greatly modified. Also there was a difference in natural response when plants were placed in a horizontal position while in an enclosure with unilateral lighting. After a natural response these plants showed a combined effect of light and gravity when treated on the original upper side of the stem, presumably due to unequal distribution of natural substances first caused by the force of gravity and then by light.

Synthetic growth substances applied at distal parts of tomato stems were extracted and identified by the colorimetric method as indole derivatives. Indolebutyric acid applied to the basal end of a horizontal stem was unequally distributed, more going to the lower than to the upper side. The extracted substance was not definitely identified as indolebutyric acid, but it was physiologically active and the color reaction strongly resembled that of the acid applied to the base of the shoot. The facts suggested that the indolebutyric acid molecule might have remained intact in the tissue.

INDUSTRIAL USES OF "SYNTHETIC" PLASTICS MAKING RAPID STRIDES, *D. C. Carpenter*. Farm Res. [New York State Sta.], 5 (1939), No. 1, pp. 1, 9, figs. 5. This is a popular discussion of plastics made from casein, cellulose, and other substances. The possibility of soybean protein as a casein substitute is mentioned, but the author doubts if any real threat to the dairy farmers' market for skim milk for casein manufacture is to be expected from soybean proteins.

NOTES ON NATIVE AND EXOTIC PLANTS IN REGION 8, WITH SPECIAL REFERENCE TO THEIR VALUE IN THE SOIL CONSERVATION PROGRAM, *L. N. Goodding*. U. S. Dept. Agr., Soil Conserv. Serv., 1938, No. 247, pp. 2+152, pls. 5. Notes are included on over 500 plants or plant groups from the Pteridophyta to the Compositae, inclusive, and an index to common and Latin names is provided. Habit of growth, habitat requirements, distribution, seed production, aboriginal uses, and characteristics affecting importance in soil binding or potential usefulness of the products of the various plants and groups are touched on. The territory covered includes the States of Arizona, Colorado, New Mexico, Utah, and Wyoming (Fremont and Hot Springs Counties).

BOILING WATER VS. STEAM STERILIZATION OF SOIL FOR SWEET PEAS, *A. Laurie* and *R. H. Simon*. (Ohio Expt. Sta.) Amer. Soc. Hort. Sci. Proc., 34 (1937), pp. 801-806. The results of the tests reported indicate but little difference in effect between steam and hot-water sterilization, provided leaching is practiced after steaming to remove the accumulation of soluble salts which cause delayed growth and slow germination. The advantages of steam are that less time is required to steam and plant afterwards, and that it is more effective in controlling fungus and bacterial diseases.

THE RAT AND RATPROOF CONSTRUCTION OF BUILDINGS, *B. E. Holsendorf*. Pub. Health Rpts. [U. S.], Sup. 131 (1937), pp. III+68, pls. 2, figs. 45. This contribution is accompanied by specifications, drawings (by P. W. Clark), and photographs and a model ratproofing ordinance.

A PRACTICAL TRAP FOR THE CONTROL OF HORN FLIES ON CATTLE, *W. G. Bruce*. (U. S. D. A.). Jour. Kans. Ent. Soc., 11 (1938), No. 3, pp. 88-93, figs. 3. A description is given of a fly trap which gives promise of effective control of the horn fly and of greatly reducing the population of the stablefly. This fly trap is of simple construction and can be built at a relatively small cost.

DEVELOPMENTS IN MECHANICAL EQUIPMENT AND METHODS IN SUGAR-BEET PRODUCTION, *E. M. Mervine* and *S. W. McBirney*. (Coop. Colo. and Calif. Expt. Stas.). U. S. Dept. Agr. Circ. 488 (1938), pp. 38, figs. 31. This circular presents, for the use of growers, the results of tests of methods and equipment designed to increase yields and reduce costs, and is also intended to suggest to manufacturers possible improvements in sugar beet production machinery. It covers planting equipment, including initial stands, planters, furrow openers, seeding rate and calibration, regulating planting depth, row spacing, hill planting, bed planting, and crust-breaking equipment; cultivation; equipment for large-scale production; cross blocking; thinning tools; beet lifters; mechanical harvesters; dump body; and hauling.

AIR-BLAST GIN PERFORMANCE AND MAINTENANCE, *A. J. Johnson* and *T. L. Bagette*. U. S. Dept. Agr. Circ. 510 (1938), pp. 18, figs. 10. Results obtained with air-blast ginning by nozzle pressures of 9, 12, and 15 in in an extensive series of tests (on cottons ranging widely in moisture content, staple length, and other conditions and qualities) show that the quality of the lint, by classifications and laboratory measurements, was slightly damaged when the nozzle pressure was reduced from 12 to 9 in, in ginning damp or wet cotton.

The 9-in pressure was less efficient and caused losses in gin turnout of 4 lb per bale on the damper cotton, as compared with the 12-in pressure. For the drier cottons, the bale-value losses for the 9-in pressure operation were smaller because of lower losses in bale weight and absence of noticeable damage to quality. On increasing the nozzle pressure from 12 to 15 in, a decline in bale value was noted for both damp and dry cotton.

Increasing the nozzle pressure from 9 to 12 in by increasing the fan speed increased energy consumption 12 per cent. It may be possible in some gins, by improvements and adequate repairs, to slow down the fans and actually save power, and at the same time provide sufficient pressure for efficient air-blast doffing. Correct air-blast pressure in a commercial gin can best be maintained by an intake valve on the fan. Gin nozzles should be given periodic attention to be sure that they are open so as to allow the free passage of air at a tangent to the gin saws. Air-blast nozzle-pressure gage and air-blast nozzle-setting and width gages are useful in operating air-blast gins economically.

GROUND WATER IN SOUTH-CENTRAL PENNSYLVANIA, *S. W. Lohman*. Pa. Topog. and Geol. Survey Bul. W-5 (1938), pp. VII+315, pls. 17, figs. 11. This report describes the geography, geology, and groundwater conditions in an area comprising 9,769 sq mi in the south central part of Pennsylvania, including 14 counties and parts of the ridge and valley physiographic province and the Appalachian Plateaus province.

The basic field data comprise tabulated records of more than 1,100 wells and springs, chemical analyses of 92 samples of ground water from representative wells and springs, and of 5 samples of water from streams. Descriptions of all public supplies that utilize ground water as a sole or auxiliary source are given. The weekly depths to water level in 4 unused wells since the fall of 1931 are given in graphic form.

AGRICULTURAL ENGINEERING RESEARCHES OF THE U. S. DEPARTMENT OF AGRICULTURE. U. S. Dept. Agr., Sec. Agr. Rpt., 1938, pp. 78-81, 119-124, 131-133, 156-160. The report briefly describes demonstration work which has resulted in the voluntary adoption by farmers of practices effective in reducing soil and water losses and flood hazards in the Coon Creek watershed area. Other brief notes cover advances in irrigation practice; farm storage findings; improvements in buildings and machinery; tillage, pest control, including successful tests of a vapor spreader similar in principle to steam cleaners for buildings, and harvesting machinery, including improved cotton pickers; work on driers, cleaners, and extractors for cotton; irrigation farming problems; and changing highway needs, including a brief discussion of future requirements and the desirabilities of uniform traffic laws adequately enforced.

(Continued on page 290)

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Agricultural Engineering Digest

(Continued from page 288)

MOTOR FUELS FROM FARM PRODUCTS, *P. B. Jacobs and H. P. Newton.* U. S. Dept. Agr., Misc. Pub. 327 (1938), pp. 129, figs. 31. Blends of ethyl alcohol with gasoline are satisfactory as fuels for present-type internal-combustion engines, especially with increased engine compression ratios and other favorable changes in design. The best blend for present conditions is that containing about 10 per cent of alcohol, although other percentages can be used. To secure uniformity of concentration and employment of alcohol blends desirable, all motor fuels should be nationally standardized.

Present crop production is found inadequate to permit alcohol production for a national 10 per cent blend without encroachment on normal feed, food, and industrial supplies. Alcohol production from present crop wastes, culls, and surpluses is estimated as unlikely to be continuously adequate for a national 5 per cent blend. Such materials would provide uncertain annual quantities of alcohol at variable costs.

Present commercial alcohol production equipment and processes are described, their adaptability to fuel alcohol production is discussed, and economic readjustments entailed in the national use of sufficient alcohol fuel to be effective in petroleum conservation are considered.

OVERHEAD CLEANER-DRYING SYSTEMS FOR SEED COTTON, *C. A. Bennett and C. S. Shaw.* U. S. Dept. Agr., Misc. Pub. 314 (1938), pp. 20, figs. 18. From 5 years' tests at the U. S. Department of Agriculture cotton ginning laboratories on equipment for from one to three-stand gins, the authors conclude that seed cotton can be dried effectively and economically by introducing heated air either into the suction line entering an overhead air-line cleaner or into an overhead out-of-the-air cleaner. The air-line cleaner-drier, within certain limitations, has proved satisfactory under test and meets the requirements of the government process. It and some of the methods of applying hot air to out-of-the-air cleaners are described.

Diagrams of the various forms of cleaner-drier here discussed are included, together with dimensioned drawings of iron pipe air heaters and photographic cuts showing home made and commercial setups and parts of installations.

ELECTRICITY FOR CURING AND STORING SWEET POTATOES.—PROGRESS REPORT ON TWO SEASONS' OBSERVATIONS IN SWEET POTATO STORAGE HOUSES OF CAPACITIES VARYING FROM 500 TO 2,000 BUSHELS, *J. A. Schaller and B. D. Drain.* Tennessee Sta. Circ. 63 (1938), pp. 4, figs. 8. A strip heater of 1,000-watt consumption is mounted across the opening in the top of a metal box over each floor ventilator. The false flooring of slats is raised on 2x8 stringers to a height of 8 in above the solid floor, and 500-watt heaters from which the floors and stringers are protected by asbestos paper are distributed evenly under the false flooring, a sheet-metal baffle over each heater serving to prevent local overheating during the curing period. Constructional details are adequately indicated in a floor plan diagram and photographs.

Removal of the stove may increase storage capacity by from 10 to 15 per cent. Uniform temperatures (maximum variation of about 2 deg Fahrenheit between floor and ceiling of a 2,000-bu storage) may greatly improve the quality of the product so cured. The power consumption was found to be about 1 kw hr per bushel. The operating costs are estimated as from 2 to 6 cents per bushel, varying with local power rates, type of construction, and percentage of the storage capacity actually filled.

MECHANIZING THE CORN HARVEST, *C. K. Shedd* and *E. V. Collins.* (Coop. Iowa Expt. Sta.). U. S. Dept. Agr., Farmers' Bul. 1816 (1938), pp. II+13, figs. 7. This bulletin briefly discusses hand-husking labor as related to acre yield; development of harvesting and husking machines from the rather ineffective single-row type of 1904, horse-drawn and ground-driven, and often capable of no more harvesting per man than could be done by hand, to the recently marketed 2-row tractor-powered machines of greatly improved efficiency, safety, and convenience; time and labor factors in machine harvesting; kind of corn adapted to mechanical pickers; field losses and other operating characteristics; and the time-saving device of a telescoping wagon tongue. Improvement in performance can be obtained by growing a corn hybrid well adapted to machine picking by picking before the crop is dry and brittle or has suffered fall-storm damage and by avoiding so wide an opening in the adjustment of the snapping rollers as to cause excessive shelled-corn loss. Where from 40 to about 80 acres per man are grown, hand husking is considered best; but when the growing equipment is so far mechanized as to permit from 100 to 150 acres per man to be grown, mechanical picking is considered the more efficient method.

The frequency of accidental injuries from corn pickers is noted, together with the precautions needed to prevent such accidents.

REPORT OF THE CHIEF OF THE SOIL CONSERVATION SERVICE, 1938, *H. H. Bennett.* U. S. Dept. Agr., Soil Conserv. Serv. Rpt., 1938, pp. 55. Some topics taken up in this report are erosion control practices (including winter cover crops, modifications in strip cropping, orchard mulching, and pasture, woodland, wildlife, and range losses under cultivation and protective cover, sedimentation studies, and the progress of various surveys.

AIR CONDITIONING, *C. A. Fuller,* in collab. with *D. Snow.* New York: Norman W. Henley Pub. Co., 1938, pp. IX+577, [pls. 2], figs. [239]. This book has been designed to furnish a complete practical guide for the calculation, design, installation, and operation of air-conditioning equipment for both large and small buildings by persons without previous engineering training. The subject is said to be so presented as to require no more than "an average knowledge of mathematics," and the mathematical requirements are, as a matter of fact, limited to very simple algebra, which is clearly explained, together with all technical terms and concepts involved in this work. The building and installation regulations taken up in the last chapter are also fully explained.

The contents are air and its properties; load calculations; duct design and air distribution; registers and grilles; heating and humidification; fans; cooling coils and air washers; fundamentals of refrigeration; compressors, condensers, evaporators, and allied equipment; well water cooling—ice cooling and storage systems; evaporative condensers and cooling towers; small store installations—unit coolers; automatic control of air conditioning; air cleaning and purification; and codes and ordinances.

ELEMENTS OF WATER SUPPLY ENGINEERING, *E. L. Waterman.* New York: John Wiley & Sons; London: Chapman & Hall, 1938, 2. ed., rev., pp. XVII+329, figs. 82. This is a textbook for students beginning the study of water-supply engineering. It was planned to meet a need encountered by the author for a text which should cover the fundamentals without being too long for thorough study in the time usually given this subject in the civil engineering curriculum. In the present revision of the original book (1934, not noted), the author has added new material concerned with mechanical equipment for water-treatment plants, the use of activated carbon for the control of tastes and odors in water supplies, the Hardy Cross method of analyzing the flow in distribution pipe networks, and the Proctor method for the design and construction of rolled-fill earthen dams.

The contents are introduction, requirements of municipal water supplies, quantity of water required, quality requirements, examinations of water to determine its quality, sources of water supply, precipitation, ground waters, the collection of ground waters, stream flow, impounding reservoirs, river and lake intakes, transportation of water, pumps and pumping plants, the treatment of water, rapid sand filtration, the removal of dissolved impurities, chlorination of water, distribution systems, distribution storage, structural features of the distribution system, operation and maintenance of waterworks systems, and waterworks finance.

PREVENTING GIN DAMAGE TO COTTON, *F. L. Gerdes* and *C. A. Bennett.* U. S. Dept. Agr. Leaflet 169 (1938), pp. 8, figs. 3. Dampness of the seed cotton and wear, inaccurate adjustment, or inaccurate speed regulation in the gin are found the main causes of gin damage. Unevenness, with resulting loss in grade and price, will result from ginning into the same bale, cotton not uniform with respect to moisture, foreign matter, fiber length, color, strength, etc.; also from nonuniform gin operation practices.

Mechanical driers, commercial or home-made, will largely eliminate the damp cotton troubles. In the gin itself, use of saws 1/16 in under size due to wear and sharpening, broken saw teeth, incorrect tooth pitch, and worn ribs are to be avoided, and saws must be run at or near the specified speeds. In brush doffing, reasonable departures from the standard of 6,666 lin ft per minute are harmless, but brushes must have full tooth mesh with the saws, and worn or saw-cut bristles caused poor doffing and gin damage. In air-blast doffing, correct nozzle pressure must be maintained and is best checked by air-blast gages. Corrections of the setting of seed, mote, and dividing boards are similarly dealt with, as is the timing of the feeder speed. Feeder speed must be equal to or less than manufacturer's specification to avoid tight seed rolls and concomitant gin damage. Roughness and projections in lint flues and condensers may also cause damage and interrupted operation.

(Continued on page 292)

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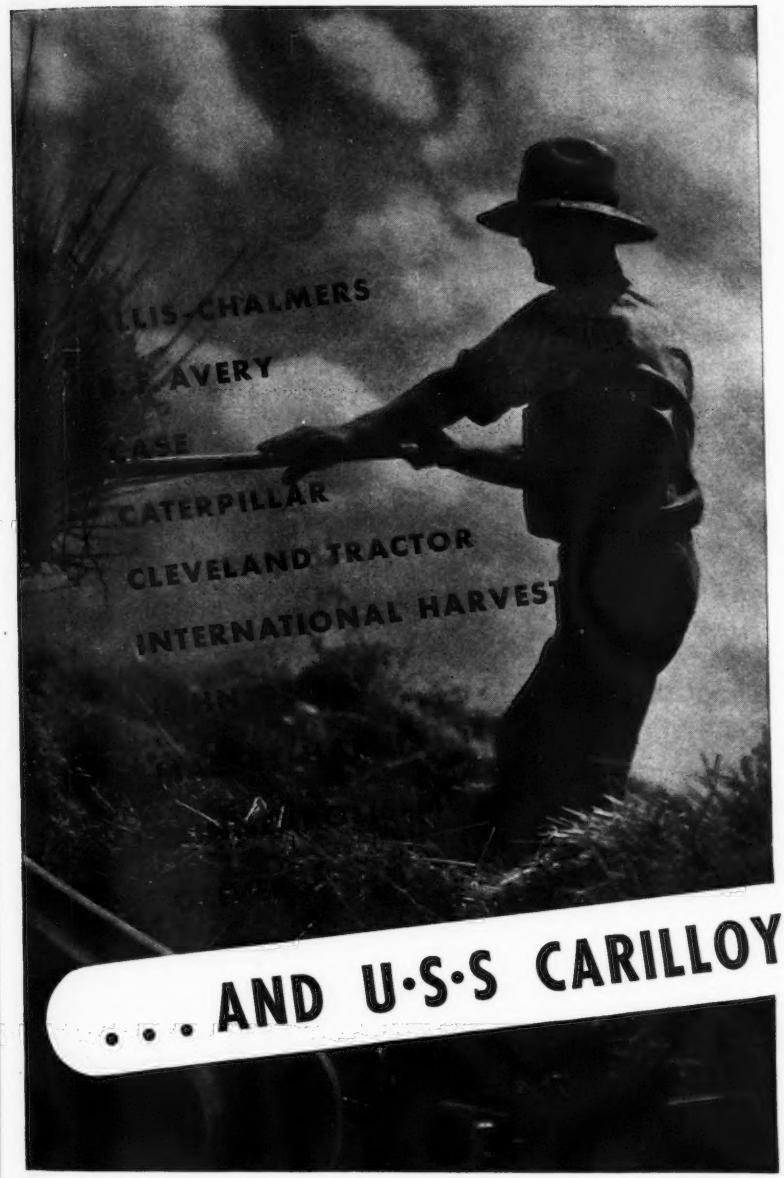

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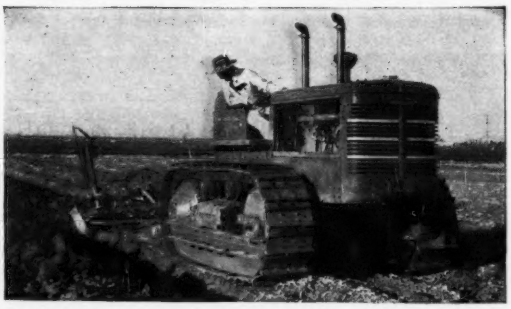

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Agricultural Engineering Digest

(Continued from page 290)

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE MICHIGAN STATION, Michigan Sta. [Bien.] Rpt. 1937-38, pp. 6, 7. This report notes a 1937 survey to determine the number (about 1,000) of combines in use in Michigan, tests showing the superiority on wet muck soils of spade lug grip low-pressure pneumatic tires over steel wheel lugs, marked superiority with respect to mechanical injury of box or crate storage of potatoes over bin storage (coop. U. S. D. A.) advantages of laminated rafter construction, and studies of porous hose and sprinkler head irrigation methods.

• AGRICULTURAL ENGINEERING RESEARCH BY THE MONTANA STATION, Montana Sta. Rpt. 1937, pp. 14, 15, 34-36. Work on water power utilization, with particular reference to homemade water lifting equipment; methods of irrigating seed and canning peas; study of water supply from Montana's watersheds, with special attention to irrigation; and range improvement by water conservation is noted. Field work on tractors adapted to burn fuel grades heavier than gasoline, investigations of the use of water wheels for water lifting and other purposes requiring power, studies of runoff and soil erosion control, and miscellaneous observations, and work on redesigning and constructing a homemade irrigation pump adapted to low lift are also mentioned.

THE USE OF ELECTRICAL HEAT IN CURING AND STORING SWEET POTATOES, *A. Meyer.* (Tenn. Expt. Sta.) Assoc. South. Agr. Workers Proc., 39 (1938), p. 104. Essentially the same information is given, with more constructional detail, in Tennessee Station Circular 63.

NEBRASKA TRACTOR TESTS, 1920-1938. Nebraska Sta. Bul. 321 (1939), pp. 45. fig. 1. This bulletin summarizes the results of 101 of the tractor 304 tests conducted since 1920 and includes data on all tractors reported as on the market January 1, 1939.

FARM MACHINERY, *C. Culpin.* London: Crosby Lockwood & Son, 1938, pp. 405, figs. 199. This book was planned as a source of information for farmers and agricultural students concerning the construction, maintenance, and use of farm-power sources, implements, and machines and the economics of mechanization. It has been the author's purpose to deal with broad principles more than with details which might quickly be out of date. "In determining the scope of the book it has been found necessary to omit reference to the constructional features of some important machines, and to treat only in outline many machines, such as electric motors, which are dealt with in detail in other books." The book is not, therefore, intended to be a complete treatise on agricultural engineering. It contains, however, much information concerning agricultural engineering developments and practices up to 1937 observed by the author in countries other than his own.

LUMBER: ITS MANUFACTURE AND DISTRIBUTION, *R. C. Bryant.* New York: John Wiley & Sons; London: Chapman & Hall, 1938, 2. ed., pp. XXIV+535, figs. 132. The purpose and plan of this book remain those of the first edition. The new edition presents the improvements in equipment and in manufacturing methods made in the 16 yr since the first edition was published, and it contains also a discussion of "the post-war adjustments in the field of lumber distribution which were designed to bring lumber production and distribution into harmony with the new economic era."

AGRICULTURAL ENGINEERING AT THE MARYLAND STATION. Maryland Sta. Rpt. 1938, p. 21. The station reports on a small electric milk pasteurizer, on electrically heated hotbed studies, and on a farm grain storage study which indicated that, whereas wheat containing 15 per cent of moisture may be stored for a short time, the use of an artificial drier will generally be necessary before long-period storage of wheat of 14 per cent or greater moisture content.

DAMMING ATTACHMENT FOR LISTERS, *L. C. Aicher* and *T. B. Stinson.* Kansas Sta. Bien. Rpt. 1937-38, pp. 127, 128, 131. Results of tests are briefly noted.

Literature Received

"ENGINEERING OPPORTUNITIES," edited by R. W. Clyne. XXV+307 pages, 5½x8 in, clothbound. A guidebook to young people considering engineering training and to engineering students faced with problems of specialization and application of their training. Twenty-six fields of industrial application of engineering training are described, each by a different author. Agricultural engineering is not included. D. Appleton-Century Co. $3.00.